The Effect of Peer-Led Supplemental Projects in a College Algebra Class at a Community College

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Abstract

Community colleges continue to provide resources for initiatives designed to help students successfully complete the traditional gateway courses, which, for mathematics, is often College Algebra. This study examined the effect of peer-led supplemental project-based instruction sessions on persistence, successful completion, conceptual understanding, and attitude toward mathematics for students enrolled in a College Algebra course at a community college. Participating instructors designed materials for supplemental sessions, which were coupled with traditional classroom instruction. Peer tutors facilitated the weekly supplemental sessions. The study employed a quasi-experimental approach to determine if students in an instructor's experimental class persisted longer, were more successful, had a deeper understanding of course concepts, or changed their attitude toward mathematics when compared to that same instructor's traditional class. The results of the study suggested that while the students found value in the sessions because of opportunities for them to feel more connected to tutors and to peers, there was no significant increase in persistence rates in the class, success rates, level of understanding of the major course concepts, or change in attitude for students in the class with the tutor-led supplemental sessions.

Dedication

This study is dedicated to the students, faculty, and staff at Johnson County Community College. I have learned most of what I know about teaching and learning from you. This study is also dedicated to the *Achieving the Dream* initiative, which has provided the impetus for all of us to learn more about community college student success.

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Chapter One

Introduction

Math matters. Be it memorizing multiplication tables, manipulating a calculator, managing a grocery budget, or passing College Algebra, mathematics impacts everyday lives. In spite of its importance, math courses remain a hurdle for many who wish to earn a baccalaureate degree in the hopes of improving their career opportunities and earning potential (Day & Newburger, 2002). Because of its position as a gateway in undergraduate programs "traditional College Algebra courses block the academic opportunities and plans of approximately 200,000 students per semester" (Small, 2007, para. 11). Moreover, students' inability to master mathematical concepts affects the world's perception of the U.S. educational system. According to the most recent collection of student achievement data through the *Trends in International Mathematics and Science Study* (TIMSS), the fourth international comparison of fourth-grade and eighth-grade mathematics and science students carried out since 1995 (U.S. Dept. of Education, 2010a, p. 1), mathematics students in the United States are merely average. While educators, business leaders, and parents may debate the causes of why U.S. students of math and science cannot successfully complete College Algebra and why they continue to score below their counterparts in Hong Kong, Singapore, Japan, and even Latvia in mathematical knowledge (Mullis, Martin, Robitaille, & Foy, 2009, p. 34), math educators are aware of one possible explanation. In the words of William H. Schmidt (1999), Professor of Education at Michigan State University, the United States' math curriculum is "a mile wide and an inch deep " (p. 1).

Community college educators in the United States have long recognized the need to improve mathematics education (American Mathematical Association of Two-Year Colleges, 2006). While the past thirty years has seen pedagogical and curriculum revision, challenges to improving mathematics teaching have been exacerbated by a preponderance of entering students who are not ready for college-level work (American College Testing, 2006). Recently, the Carnegie Foundation for the Advancement of Teaching (2010) released a report stating, "up to 60 percent of community college students who take the placement exam learn they must take at least one remedial course (also called developmental education) to build their basic academic skills" (para. 1). Data on college-readiness in mathematics disaggregated by ethnicity demonstrated an even greater disparity.

> In mathematics, only 10 percent of white 17-year-olds, 3 percent of Hispanic 17-year-olds, and 1 percent of African-American 17-year-olds can solve multi-step problems. In addition, while 70 percent of white students can complete moderately complex mathematical procedures, only 38 percent of Hispanic students and 27 percent of African-American students can perform at the same levels. (Bill and Melinda Gates Foundation, 2003, p. 3)

Once in a developmental math sequence at a community college, those same students may find it difficult to progress into college-level work. According to Bailey, Jeong, and Cho (2010), up to 70 percent of community college students referred to developmental mathematics do not successfully complete the sequence of required courses. The inability of students to complete a developmental math sequence directly affects graduation rates for colleges. In fact, the United States now ranks 12th among the 36 developed nations in the percentage of young people with college degrees (Herbert, 2010, p. A15).

Background

On October 24, 2005, the Lumina Foundation for Education awarded more than $28,000,000 in grants to help community college students succeed (Lumina Foundation, 2005). The Lumina Foundation for Education (2005) created the *Achieving the Dream* (AtD) initiative in response to the low achievement and low graduation rates of minority community college students, concluding that many community college students struggle in mathematics, reading, and writing, especially students of color, students of poverty, and first-generation college students (Achieving the Dream, 2009, p. 1). A focus on minority student success comes at a time when the minority population in our country continues to grow significantly; the percentage growth in population since 1994 has been higher among Asians, Hispanics, and Blacks than for non-Hispanic Whites (U.S. Census Bureau, 2011). Figure 1 provides a graphical representation of this national growth.

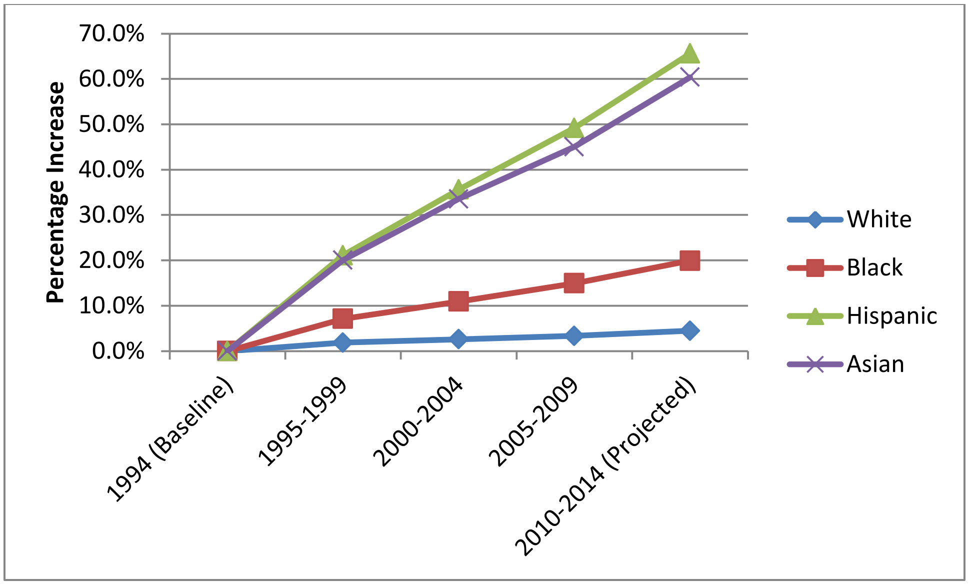

Figure 1. Growth Rate of U.S. Population by Ethnicity 1994-2014. From U.S. Census Bureau, 2011.

Community colleges experienced an increase in diverse student populations that mirrors these national trends. The American Association of Community Colleges (AACC) reported that since 1996, community college student populations became more diverse; among Blacks, 16% increase; Hispanics, 143% increase; and students who identify as Asians, 346% increase (as cited in Nettles & Millett, 2011, para. 4). In creating the AtD initiative, the Lumina Foundation (2005) recognized that the combination of greater numbers of minority students entering college with low aptitude in mathematics among some of those minority populations could significantly worsen student success rates in U.S. community colleges.

Colleges accepted as Achieving the Dream schools "agree to engage faculty, staff, and administrators in a process of using data to identify gaps in student achievement and to implement strategies for closing those gaps" (Achieving the Dream, 2009, p. 7). The Lumina Foundation expects participating colleges to create a climate that ensures the success of all students, regardless of the level of preparation of those students when they enter. Colleges participating in AtD have experimented with a variety of initiatives designed to increase the mathematical literacy of their students, focusing many efforts on students who test into developmental mathematics (Achieving the Dream, 2010). Recent math initiatives implemented by participating colleges have included establishing learning communities, providing struggling students with early intervention programs, and creating supplemental learning activities for especially difficult classes (Achieving the Dream, 2010). What differentiates the AtD movement from other instructional initiatives is that any AtD college must provide evidence of the effectiveness of initiatives using data and research (Lumina Foundation for Education, 2005). While educational innovations borne out of AtD have led to improvement in some areas of mathematics, no college has been able to conclude that any one strategy is most effective for teaching mathematics to all community college students (Achieving the Dream, 2010).

Statement of the Problem

Johnson County Community College (JCCC), an open admissions community college located in a wealthy suburb of Kansas City, was the first college in Kansas chosen to participate in the Achieving the Dream initiative (Johnson County Community College, 2011a). As part of that participation, the college was required to study retention and success data and report those data to the AtD database. Upon first glance, it would not seem that JCCC would fit the profile for inclusion in the AtD initiative. The college is located in a county with award-wining public school systems (Blue Valley School District, 2011; Olathe Public Schools, 2011). The percentage of minority students, first-generation college students, and students of poverty at JCCC, while increasing, is lower than the national average (Johnson County Community College, 2010a). However, the lack of success among underprepared students is a commonality JCCC shares with other schools across the country. In fact, a student at JCCC who begins work at the college in the lowest level mathematics class has only an 11% chance of completing College Algebra, the traditional gateway or gatekeeper mathematics course (Johnson County Community College, 2011c). The community college experienced a significant increase in the percentage of African American and Latino students, which mirrors demographic trends in the county (U.S. Census Bureau, 2010). In a recent analysis of incoming JCCC students, 83% of entering students tested into developmental math, reading, or writing (Johnson County Community College, 2011c). Thus, although JCCC is located in a county with excellent K-12 education, the community college experienced the same phenomenon other AtD schools face: students arrive at the college unprepared for college-level work.

During the 2008-09 and 2009-10 academic years, the college identified areas of significant achievement gaps, and began to develop programs and initiatives to address them. The data analysis indicated the greatest achievement gaps occurred among students who tested into the lowest level reading, writing, or mathematics courses as well as students who were enrolled in gateway courses (Composition I for writing and College Algebra for mathematics) (JCCC, 2010b). For mathematics, the college decided to develop programs that would: 1) Increase the success rates among students in developmental mathematics classes, especially those in the lowest-level classes; 2)

Increase the success rates among students enrolled in College Algebra (JCCC, 2011b). The JCCC website described the process of selecting its improvement strategies this way:

> Each college participating in Achieving the Dream spends their [sic] first year with the program building opportunities for critical review of data, and deliberative dialogue among stakeholders. Through this process, different colleges identify different needs—some focus on minority student success, for example, while others look at adult returning students. At JCCC, college stakeholders have identified developmental education as the most pressing challenge. (Johnson County Community College, 2011b, para. 1)

Instructors and administrators at participating colleges were expected to work together to create strategies to improve instruction at their institutions. At JCCC, math instructors identified two major problems: not enough students completing the developmental math sequence and not enough students passing College Algebra. To that end, the dean of the mathematics division at JCCC implemented math initiatives, which included the introduction of peer-led, supplemental project-based College Algebra classes, attempting to improve success rates among students in the gateway mathematics course (Johnson County Community College, 2011b).

Significance of the Study

Since the early 1990s, the educational community has intensified research to improve instruction in mathematics (American Mathematical Association of Two-Year Colleges, 2006; Mullis, et al., 2009). As part of that research, focusing on community college student success in mathematics, the results of this study could help teachers at JCCC make better curriculum and pedagogical decisions. This study also complements the growing body of research emerging from the nascent AtD movement. The targeted initiatives undertaken by JCCC to close the achievement gaps for students enrolled in College Algebra combined elements of effective educational practice including project-based instruction, supplemental instruction, and learning communities. While studies have shown each to be an effective instructional strategy in certain settings (Boaler, 1998; Arendale, 2000; Day & Frost, 2009), limited research exists regarding the effectiveness of the combination of two or more of those elements. This study provides new research into the effectiveness of the combination of instructional strategies when implemented within a community college setting.

Purpose Statement

The purpose of this study was to determine the effect of peer-led supplemental project-based instruction sessions for students enrolled in a College Algebra course at a community college. The study examined elements of supplemental mathematical projects and tutor-facilitated supplemental instructional sessions with persistence in the course, successful outcomes defined as a final course grade of “C” or higher, performance on the common final exam, and change in attitude toward mathematics. An additional purpose of the study was to determine if stakeholders’ perceptions indicated students would be more likely to succeed in mathematics courses because of their experiences with the peer-led supplemental project-based instruction sessions.

Delimitations

Because the strategies to improve student success in mathematics are unique to the institution implementing them, the greatest delimitation in this study is the fact that the students studied were from one institution only. As explained earlier, JCCC has a smaller percentage of minority students than perhaps all other community colleges participating in the AtD initiative. Therefore, readers may or may not be able to generalize these findings to other colleges, especially those with higher percentages of minority populations.

Instructors chosen to participate in the study each taught two sections of College Algebra during the fall 2010 semester or the spring 2011 semester; one section employed supplemental project-based sessions and one did not. Student selection for the two sections was not random. One of the delimitations of employing a design that does not include random selection of participants is the fact that little is known about the equivalence of the experimental and control groups prior to the experiment. For this reason, it is "difficult to draw valid conclusions about treatment effect based solely on posttest information" (Cook & Campbell as cited in Lunenburg & Irby, 2008, p. 50). The inability to assign participants randomly to either the experimental group or the control group for all sections of the classes studied was inherent in this design and the researcher acknowledges that delimitation. The reason for this delimitation is that the additional time for all but one of the experimental classes had to be scheduled and students had to know they were signing up for this additional hour. Because the selection of student participants was not random, any significant results in the study might be explained by differences in the types of students who either selected this additional hour or chose not to select it. Finally, the supplemental instructional sessions required students to spend an additional hour of class time beyond the normal class time. Any significant positive results from this study may have resulted from increased time-on-task rather than the effect of the projects or the supplemental sessions themselves.

The relatively small number of students (n = 3), tutors (n = 2), and instructors (n = 4) chosen for interviews was one of the delimitations of the qualitative component of the study. Students chosen for interviews may or may not have represented the population of students taking College Algebra at JCCC. In addition, the researcher interviewed students after the semester had concluded; it is possible that some of the students interviewed did not remember critical moments that could have occurred during the semester in which the student took the class.

Finally, this study combined several strategies including project-based learning (Boaler, 1998; Boaler, 2008), supplemental instruction (Arendale, 2000; Arendale, 2004), peer-led team learning (Gosser, et al., 2001; Gafney & Varma-Nelson, 2008) and learning communities (Tinto 1998; Smith, MacGregor, Matthews, & Gabelnick, 2004; Day & Frost, 2009). The use of a combination of pedagogical strategies may have made it more difficult to isolate any variable in studying the effect of the peer-led supplemental project-based instruction sessions.

Assumptions

The researcher assumed that instructors used the same instructional strategies within the classroom, both for the experimental section and the control section. While the researcher acknowledges that math instruction can vary from instructor to instructor, the requirement of a common final exam ensured overall consistency of content within all classrooms in the study.

Research Questions

The following research questions were examined to determine the effect of peer-led supplemental project-based sessions in a College Algebra class at a community college:

1. To what extent do peer-led supplemental project-based instruction sessions increase the average number of days students persist, the percentage of students who successfully complete, and the level of understanding of mathematical concepts?
2. To what extent do peer-led supplemental project-based instruction sessions change attitudes toward mathematics?
3. To what extent do peer-led supplemental project-based activities coupled with classroom instructional strategies contribute to overall success for students in a College Algebra class at a community college?

Definition of Terms

Achieving the Dream (AtD). An initiative begun in 2005 by the Lumina Foundation for Education, Achieving the Dream (AtD) was created to close gaps in student achievement, primarily students of color, students of poverty, and first-generation college students (Achieving the Dream, 2009). The first cohort of AtD colleges included 27 community colleges in five states; AtD has since expanded to over 100 institutions in 22 states serving over one million students (Achieving the Dream, 2009). The Lumina Foundation provides financial resources for colleges to create initiatives whose purpose is to close achievement gaps among students (Lumina Foundation for Education, 2005).

College algebra. The Johnson County Community College course outline defines College Algebra as, "A functions approach to algebra, which includes linear, quadratic, polynomial, radical, rational, exponential, and logarithmic functions. The course also contains methods of solving systems of equations including matrices. The course concludes with an introduction to sequences, series, and the binomial theorem" (Johnson County Community College, 2011d).

Common final exams. With very few exceptions, all JCCC mathematics instructors teaching the same course administer a common departmental final exam (Johnson County Community College, 2010d). The math division enforces this policy regardless of the modality of instruction--online, face-to-face, computer assisted, and so on (Wilson, 2008).

Core question analysis (CQA). All JCCC math final exams have questions spanning material taught over the entire semester, of which eight to ten questions tie directly to the course outcomes as written on the JCCC Course Outline (Wilson, 2008). These eight to ten exam questions are called Core Questions. Core Question data are analyzed at least once every three years (Johnson County Community College, 2010d).

Learning communities. A term used throughout the study, learning communities describes the traditional *college* learning community (Price, 2005; Washington Center for Improving the Quality of Undergraduate Education, 2011). College learning communities have some overlapping elements with the K-12 term Professional Learning Communities (PLCs) but are not equivalent (DuFour, DuFour, & Eaker, 2008). College learning communities are found in multiple formats, including linked courses, coordinated courses, and thematic courses (Cross, 1998; Tinto, 1998).

Project-based learning. Jo Boaler (1998), professor at Stanford University, formalized the term Project Based Learning (PBL) in the mid-1990s. PBL utilizes real-world applications in order to provide students with a better understanding of how to apply the theory of the mathematics the students are learning (Boaler, 1998).

Student success in mathematics. As defined by both AtD and JCCC, a student successfully completes a mathematics course if that student earns at least a grade of C (Wilson, 2008; Achieving the Dream, 2010; JCCC, 2010d).

Supplemental instruction (SI). SI is “an academic assistance program that utilizes peer-assisted study sessions” (University of Missouri-Kansas City, 2010, para. 1). David Arendale, professor at The University of Missouri-Kansas City co-developed SI in the 1970s (University of Missouri-Kansas City, 2010).

Overview of Methodology

Using a quasi-experimental, mixed-methods approach, the researcher examined data on students (n=243) taking College Algebra in either the fall of 2010 or the spring of 2011 to determine if elements of peer-led supplemental project-based instruction sessions helped students succeed in the course. Instructors chosen to participate in the study taught two sections of College Algebra during the same semester; one section taught by each instructor was the experimental section and included the peer-led supplemental project-based instruction sessions. The other College Algebra section taught by that same instructor, designated as the control section, did not have peer-led supplemental project-based instruction sessions attached. A statistical analysis of the average number of days students persisted in the course, the percentage of students who successfully completed the course, and the level of understanding of course concepts was performed.

At the beginning of the semester, instructors taking part in the study administered an attitudinal survey to their students. Near the end of the course, those instructors re-administered that same survey to their students. A statistical analysis of attitudinal data was performed to determine whether attitude toward mathematics changed significantly pre- to post. Additionally, two instructors during the spring 2011 semester created online discussion boards for which students in the experimental groups responded to prompts about the supplemental sessions. Instructors and tutors participating in the study identified students for interviews after the semester concluded. Three students purposively chosen for further study participated in a series of three interviews to garner their perspective on which elements of project-based activities helped them succeed and which elements created barriers to success. Instructors and tutors who participated in the study were also interviewed.

Summary and Organization of the Study

This chapter provided a rationale for the importance of studying student success in College Algebra, which is often the gateway mathematics course at community colleges. A background for the study, which included statistics on the traditionally low rates of success in College Algebra among community college students, followed. Next, the chapter highlighted the significance and purpose of the study, in which the effect of peer-led supplemental project-based sessions on persistence, success, understanding, and attitude were studied. The chapter continued with delimitations of the study, assumptions, the research questions examined, definitions of key terms used throughout the study, and a brief overview of the methodology used. Chapter two provides an extensive review of the pertinent literature including a more detailed explanation of the

Achieving the Dream initiative, a brief history of mathematics education, and research on innovative and emerging pedagogical practices in mathematics. Chapter three provides the reader with a detailed description of the methodology. Chapter four gives results of the study. Chapter five presents interpretations, findings related to literature, and recommendations for additional research.

Chapter Two

Review of the Literature

This review of literature provides references demonstrating the variety and depth of pedagogical initiatives implemented by educational institutions in the past 100 years to improve mathematical instruction. This chapter contains three major sections: a) reasons for concern, including a detailed description of the Achieving the Dream initiative and a summary on the challenges of developmental education; b) a brief history of teaching mathematics in the United States, which includes a timeline of the pedagogical shift from a focus on classroom strategies to a focus on the individual learner; and c) promising practices in mathematics, detailing recent instructional strategies and examples of community colleges implementing those strategies.

Reasons for Concern

Thomas Bailey (2003) reported that while “70% of entering community college students indicated they aspired to earn a bachelor’s degree, only 10% completed that degree” (p. 1). In that same study, “Only 25% of those community college students who planned to complete a bachelor’s degree transferred to a 4-year institution” (Bailey, 2003, p. 1). Often, the greatest hurdle students encounter as they attempt to complete a degree is the mathematics requirement. Attewell, Lavin, Domina, and Levey (2006) noted that while 68% of community college students pass all developmental writing courses and over 70% pass the developmental reading courses, only 30% pass the developmental math sequence. This inability to complete the developmental math sequence prevents students from enrolling in and successfully completing a college-level mathematics course, which is often College Algebra. Bailey, Jeong, and Cho (2010) found that only

20% of students who enrolled in remedial courses ever completed a required college-level math course.

For at least 10 years, state legislatures have been vocal about the need to improve outcomes in higher educational institutions, often tying funding to evidence of improvement (Fox & Hackerman, 2003). Support for improving student success among community college students has even extended to the highest office in the United States. On July 14, 2009, President Barack Obama introduced the American Graduation Initiative (AGI), making one of his top educational priorities to "stimulate innovative policies and practices to improve the quality of the community college experience" (American Association of Community Colleges, 2010, p. 1).

Some lack of academic success among community college students can be attributed to the fact that many students come to community college unprepared, often in the area of mathematics. Zeidenberg (2008) reported that, "42% of first-year students at two-year colleges were enrolled in at least one developmental course" (p. 53), while Hinshaw (2003) found a higher percentage among North Carolina community college students, noting that 60% of entering students placed into one or more developmental courses. More recently, Attewell et al. (2006) found that 58% of students who attended a community college took at least one developmental course. In a longitudinal study spanning nearly 30 years, Adelman (2004) concluded, "the proportion of students starting in community colleges who required at least one remedial course showed no significant change, remaining in the 61–63 percent range" (p. viii). An ACT (2010) study, reporting the percentage of high school students prepared to enter higher education, found that only "one-third to one-half of all eleventh-grade students are reaching a college and career readiness level" (p. 3). When colleges disaggregated data on student preparation based on race, the numbers became even more sobering. For example, Bailey, Jenkins, Jacobs, and Leinbach (2003) found that "all minority populations graduate at lower rates than Whites" (p. 49). A recent ACT study noted, "The percentages of Caucasian students who met or exceeded the performance of college- and career-readiness students were uniformly higher than the corresponding percentages of African-American and Hispanic students" (American College Testing, 2010, p. 3).

Educators may disagree on whether the problem of limited student success is one of preparation or ineffective teaching at the community college. However, educators can agree on the need to increase student success rates, noting,

> Fewer than one-fourth of individuals who began their postsecondary education at a community college in 1989-90 had attained an associate degree (17.5 percent) or a certificate (5 percent) at the first institution in which they enrolled by spring 1994, five years later (Nettles & Millett, 2011, para. 6).

A more recent study of over 250,000 community college students in California found that "Six years after enrolling, 70% of degree-seeking students had not completed a certificate or degree and had not transferred to a university" (Sacramento State University, 2011, para. 3).

Achieving the Dream. In 2005, the Lumina Foundation for Education established a new initiative to help community college students succeed (Lumina Foundation for Education, 2005). The Lumina Foundation called the new program Achieving the Dream (AtD), created to help traditionally underserved populations of college students succeed. Those underserved populations include students of color, students of poverty, and first generation college students (Achieving the Dream, 2009). Studies showed that while the number of African Americans and Latinos enrolled in colleges and universities has increased since 1994, those two ethnic groups continue to be underrepresented in higher education (Perna, 2000; Bettinger & Long, 2009; Warnock, 2009).

As of 2010, over 100 colleges in 22 states were a part of AtD, making it the largest non-government initiative in community college history (Achieving the Dream, 2009). The AtD literature provides a road map for participating colleges to examine their practices and determine how they might address gaps in student success (Achieving the Dream, 2005a). Achieving the Dream (2005b) requires colleges to assess "the effectiveness of their strategies, institutionalize approaches that prove successful, and share their findings widely" (p. 1).

The Lumina Foundation for Education (2010), through the introduction of AtD, created a "big goal": 60% of U.S. citizens will have at least a two-year degree or certificate by the year 2025. The Lumina Foundation provided data on completion rates for each State, showing residents how far they will need to go to reach that "big goal." For example, the Lumina Foundation (2010) concluded that if Kansas continues with the same graduation rates it had from 2000 to 2008, the state would only have a graduation rate of 51%, far short of the stated goal of 60%.

Both the Lumina Foundation and the American Association of Community Colleges cite a need for better data and information to determine why students at community colleges are unsuccessful (Nettles & Millett, 2011). Prior to the introduction of AtD, research on community college student success was limited. Ernest Pascarella and Patrick Terenzini (1991) used a "narrative explanatory synthesis" as they performed an analysis of over 3,000 studies of college student attitudes and behaviors (p. 10). While the number of studies included in the synthesis was substantial, most students in the 3,000 studies reviewed by Pascarella and Terenzini (1991) were, "Non-minority students of traditional college age (eighteen to twenty-two), attending four-year institutions full-time and living on campus" (p. 13**)**. According to the American Association of Community Colleges (2011), the average age of community college students is 28 years. The conclusions reached by Pascarella and Terenzini (1991) may not necessarily apply to community college students, as evidenced by the authors' statement:

> Because the vast majority of studies of college students have focused on traditional-aged undergraduates (that is, those eighteen to twenty-two years old), the theories and models selected for review deal principally with change or growth among that group of undergraduates. We do not intend to suggest by this that older students are unimportant or that theories of change over the full, human life span are without merit for understanding the effects of post-secondary education on individuals. Indeed, these life-span theories are becoming increasingly important as larger numbers of older students enter (or return to) college. (p. 17)

Community colleges have their share of traditional students; however, many non-traditional students also attend community colleges, including adult students returning to college to change careers. What most differentiates the community college student population from the population at four-year colleges is the predominance of part-time students. In 2001, "Only 36 percent of community college students attended full-time, while 71 percent of four-year college students attended full-time" (U.S Department of Education, 2003, p. 1). A more recent survey confirms that statistic noting that the percentage of community college students attending part-time stands at 38% (Center for Community College Student Engagement, 2008, p. 2).

That community college students differ from other college students has led some researchers to study factors that specifically engage community college students. Kay McClenney began conducting the Community College Survey of Student Engagement (CCSSE) in 2002 (Bradley, 2010). CCSSE data collected over the past eight years have contributed to the understanding of how community college students differ from students at four-year universities and what community college students need to be successful. Those data underscore an important fact: unless community colleges engage their non-traditional students, those students will not be successful (McClenney, McClenney, & Peterson, 2007).

Boroch, et al. (2010) expanded the work begun by Pascarella and Terenzini, providing a national forum for sharing characteristics of programs and initiatives that help traditionally underserved students successfully complete a college degree or certificate. The AtD movement has inspired researchers to disaggregate data by gender, ethnicity, and social class, which previously had been missing from the literature (Secada, 1992; Lubiensky, 2000). Community colleges in California, Texas, Maryland, and Florida have been leaders in research focusing on traditionally underserved community college student populations, making their results available to all AtD member institutions (Achieving the Dream, 2010).

The Challenges of Developmental Education. As faculty and staff at community colleges expand research to examine effective practice, many focused their studies on two main areas: the number of students needing remediation and the number of students who cannot pass the so-called gateway math and English courses (Achieving the Dream, 2010). Remedial education, also called developmental education, has long been a cornerstone of the mission of community colleges (American Association of Community Colleges, 2000). However, the number of students testing into remedial or developmental math continues to climb at the same time the public in many states is becoming less patient with a system that cannot demonstrate effectiveness in the programs targeted toward students needing remediation in mathematics (Merisotis & Phipps, 2000). In a 2000 position statement, the American Association of Community Colleges (2000) wrote:

> There are no indications that escalating costs, declining revenue, and increasing demands for services will change for community colleges in the foreseeable future. As all levels of education address the problems of underprepared students—whether the result of legislative mandates, accrediting agency requirements, or questions about institutional performance—demands on community colleges will increase and call for bold and creative thinking. Colleges must identify, adopt, adapt, and implement the most successful policies and strategies possible to improve the academic performance of their diverse student populations and, as a result, the quality of life in their communities. (para. 6)

Bailey (2009) reported that developmental mathematics education has not been effective for students who are unprepared for college work noting that, "There is no statistically significant effect of math remediation on completing a certificate or associate degree, or on transferring to a public four-year college" (p. 8). Grubb and Cox (2005) identified four components of education—instructors' approach to teaching, students' attitudes towards learning, curriculum as evidenced by the sequence of classes, and institutional requirements—arguing that only when all four elements align can successful developmental instruction occur.

When colleges calculate the cost of remediation, the breadth of the problem becomes even more pronounced. Bettinger and Long (2009), in an Ohio study, noted that " public colleges spent $15 million teaching 260,000 credit hours of high school-level courses to freshmen in 2000" (p. 737). Kraman, D'Amico, and Williams (2006) included lost wages students would be otherwise earning in their calculation, writing, "taxpayers provide about a billion dollars a year to cover the direct and indirect instructional costs of remedial courses" (p. 3). Saxon and Boylan (2001) examined five published studies on the costs of remedial education in concluding an investment in remedial education today, "may negate significantly higher costs of social dependency in the future" (p. 5).

In 2009, the California Community Colleges Chancellor's Office (CCCCO) along with EdSource conducted the most comprehensive study to date to determine the effectiveness of developmental education in California. The 2010 report, titled *Something's Got to Give*, recognized the increasing number of students needing remediation (and the associated cost) while dealing with limited resources available to address this population of students. In this study, the researchers examined data from over 122,000 entering community college students in California (EdSource, 2010). The results of the study provided strong evidence that students who began college work at the lowest developmental level were unlikely to graduate (EdSource, 2010). An analysis of data disaggregated by race and ethnicity described an even greater challenge for African Americans and Hispanics: while 28% of White students began at the highest level of developmental math, only 16% of Hispanics and 13% of African Americans began there. In California, as is the case for most of the nation, the percentage of African Americans and Latinos in the United States has continued to climb (U.S. Census, 2010). The United States, and California in particular, has experienced a confluence of an increasing population that tends to test into developmental mathematics with a system that makes it increasingly difficult for students testing into the lowest level mathematics to ever graduate.

The CCCCO study reported other disturbing trends in their examination of data on success in the remediation of community college mathematics. For example, the researchers found that students who tested into the lowest levels of mathematics were less likely to aspire to transfer to a four-year institution (EdSource, 2010). Finally, the researchers identified another issue: the timing of when students began work on developmental math. The results of the study suggested that students testing into the lowest level mathematics were the most likely to delay taking mathematics, and that this delay led to further academic challenges (EdSource, 2010).

Still another challenge of effective practice in developmental education is ensuring a commitment to remedial education from college leadership. Boroch, et.al,

(2010) concluded that, “changes in institutional conditions… also result in fundamental shifts of organizational focus that may have an impact on the delivery of developmental education” (pp. 15-16). Roueche and Roueche (1998) also found that committed leadership was an important component in effective developmental education programs. Boylan and Saxon (2002), in a study of developmental education programs in Texas, found a strong correlation between colleges with high rates of student success and leaders who made development education a priority.

A student’s attitude toward mathematics may have some effect on that student’s ability to succeed. Studies on the link between attitude and achievement in mathematics even go back as far as the late 1960s. Neale (1969) reported, “Positive or negative attitudes towards mathematics appear to have only a slight causal influence on how much mathematics is learned, remembered, and used” (p. 636). Ma and Kishor (1997) in a meta-analysis of 118 studies found a small but positive correlation between attitude and achievement, with the correlation more pronounced when disaggregated by gender or race. Ma (1999), in a meta-analysis of 26 studies found a slight correlation between math anxiety and mathematics achievement, concluding that a reduction in mathematical anxiety levels might be associated with “an improvement from the 50th to 71st percentile in mathematics achievement for an average student highly anxious about mathematics” (p. 532). These studies, performed years apart, suggest a small correlation between attitude and achievement in mathematics among elementary and secondary students. However, even today, limited research is available that examines whether a correlation exists between attitude and achievement for community college students.

As community colleges design programs geared toward an increasing number of underprepared students, more colleges are examining existing research on program effectiveness (Boroch, et al., 2010). The Lumina Foundation (2010) through its introduction of the Achieving the Dream initiative, has encouraged community colleges to focus on strategies to increase the number of students who will successfully complete the gateway mathematics course.

Summary of concerns. Community college leadership, recognizing the high cost yet importance to society of effective remediation, have recently implemented programs to improve student success rates, focusing much of their efforts on developmental education. Many of these new programs have been borne from the Achieving the Dream (AtD) initiative, which targets underrepresented student populations, such as students of color, students of poverty, and first-generation college students. Data from the AtD initiative confirm that students testing into the lowest level math courses often do not progress to college-level math work; AtD has encouraged colleges to focus efforts on developing strategies to improve student success in developmental and gateway mathematics courses. In order to understand the context and theoretical basis for strategies undertaken by community colleges across the country, this chapter continues with a short description of the history of teaching mathematics.

A Brief History of Teaching Mathematics in the United States

In 1922, Edward L. Thorndike published *The Psychology of Arithmetic,* in which he described how humans learn mathematics. Thorndike (1922) argued the importance of “speed and accuracy” in solving mathematical problems (p. 31). Thorndike’s philosophy of quantitative reasoning is apparent in this quote: “It appears, at least to the author, imperative that checking should be taught and required until a pupil can add single columns of ten digits with not over one wrong answer in twenty columns" (p. 33). Thorndike's work thus formed the basis of the drill and practice approach and the focus on getting the right answer that guided mathematics instruction throughout the early to middle part of the twentieth century. According to English and Halford (1995), this approach led to "a fragmentation of arithmetic into many small components of facts and skills to be taught and tested separately" (p. 2). Five years later, psychologists at the Institute of Educational Research published *The Measurement of Intelligence,* in which they discussed the theory of connectionism, which expanded Thorndike's earlier work (Thorndike, Bregman, Cobb, & Woodyard, 1927). Thorndike, et al. (1927), describe connectionism through a mathematical example: "In a child who has learned the multiplication table, the idea 2 times 5 will always be followed by the idea 10, unless some contrary force prevails" (p. 417). English and Halford (1995), in their summary of Thorndike's body of work, concluded learning requires rote practice, learning is dependent upon previous knowledge and experience, and the number of connections deepens learning (Chapter 1).

In the 1930s and 1940s, mathematics instruction moved from a pedagogy focused on drill and practice to one focused on conceptual understanding. Two schools of thought emerged: one believed students learned mathematics best through experiential activities; the other believed students learned mathematics best by studying mathematical structures. Anna Johnson Pell Wheeler, one of the most important female mathematicians in the early twentieth century, advocated the importance of learning mathematics in context (Riddle, 1995). William Brownell, on the other hand, believed that “meaning is to be sought in the structure, the organization, the inner relationship of the subject itself” (as cited in English & Halford, 1995, p. 4). According to Kilpatrick and Weaver (1977), Brownell believed drill and practice should only occur after students understood the underlying mathematical theory. Elements of both Wheeler’s and Brownell’s work are predominant in the way mathematics instructors taught in the middle to late twentieth century.

In the 1960s, the mathematics education community responded to one of the most profound moments in world events. With the Soviet launch of Sputnik, and the subsequent Woods Hole conference in 1959, the so-called “New Math” was introduced to the educational system (English & Halford, 1995). Educators believed they needed to redesign the mathematics curriculum in order for the United States to remain competitive with other powerful nations. The 1960s birthed a curriculum that included “explicit teaching of set theory… as well as traditional Euclidean geometry” (English & Halford, 1995, p. 7). Looking back, this experiment in teaching a more conceptual and abstract mathematics curriculum is generally regarded as a failure (Usiskin, 1999). Part of the reason for this failure could have been because young students who, according to psychological theory, had not yet developed the ability to think abstractly were expected to learn mathematics through an abstract pedagogy. According to Piaget’s cognitive development theory, the formal operational stage, “demonstrated through the logical use of symbols related to abstract concepts,” occurs in adolescence and adulthood (Huitt & Hummel, 2003). Only 35% of high school graduates in industrialized countries reach this stage and many adults never reach it (Huitt & Hummel, 2003).

Another reason the "new math" might not have had the intended positive outcomes is that it was difficult for students to connect what they were learning with their prior knowledge. David Ausubel (1978), a cognitive psychologist, wrote, "if I had to reduce all of educational psychology to just one principle, I would say the most important single factor influencing learning is what the learner already knows" (p. 163). The new math was difficult to tie to prior knowledge because its theoretical nature did not lend itself to immediate application. As Marton and Booth (1997), advocates of the phenomenological approach to education, wrote, "any psychological entity such as learning cannot exist without an object. There is no learning without something learned" (p. 115).

In the latter part of the 1980s, mathematics educators began to advocate for incorporating a constructivist approach in mathematics education. The National Council of Teachers of Mathematics (NCTM) created a conceptual framework for how mathematics should be taught that included creating a classroom where students could "acquire clear and stable concepts by constructing meanings in the context of physical situations" (National Council of Teachers of Mathematics, 1989, Assumptions, para.1). Even Thorndike's (1922) early work foreshadowed this emphasis on practicality, stating:

> The distinction between the description of a *bona fide* problem that a human being might be called on to solve out of school and the description of imaginary possibilities or puzzles should also be considered…[certain mathematical problems] are bad because to frame the problems one must first know the answers, so that in reality there could never be any point in solving them. (p. 47)

Gloria Ladson-Billings (1997), professor of curriculum and instruction at the University of Wisconsin Madison, described mathematics classes prior to the NCTM standards as "repetition; drill; convergent, right-answer thinking; and predictability" (p. 699). The NCTM standards, which emphasized small group work, estimation, and problem solving, thus became the guiding principle for mathematics education for the next 10 years. Instead of creating a curriculum where problem solving was an end in itself, the NCTM standards emphasized problem solving as a *means* to learn mathematical theories and procedures (Lubiensky, 2000). At the time of their creation, the NCTM standards were embraced by the major mathematical organizations, including the Mathematical Association of America (MAA) and the American Mathematical Association of Two-Year Colleges (AMATYC) (Mathematical Association of America, 2011).

Not everyone's reaction to the NCTM Standards was positive. Some critics of the NCTM Standards used the term *fuzzy math* or *whole math* to describe the shift from paper-and-pencil computation toward more emphasis on calculators and utilizing group work as a problem-solving strategy (Kilpatrick, Swafford, & Findell, 2001; Boaler 2008). Lynne Cheney (1997) criticized the lack of research that led to the shift away from so-called traditional math teaching, when she wrote: "These 'theories' [cooperative learning, applications to social issues] are nothing more than stereotypes, backed-like much of whole math-by research so anecdotal it barely deserves the name" (p. A22). Martin Gardner, in a Public Broadcasting System videotape series on math instruction in 1998, claimed, "It is estimated that half of all pre-college mathematics is now being taught by teachers trained in fuzzy math" (as cited in Kilpatrick, et. al, 2001, p. 103). Carnine and Gersten (2000), in an article about the role research should play in education, lamented the fact that the NCTM standards were not based on experimental or quasi-experimental research. Some parents also criticized the new mathematics, worrying that "students were no longer learning standard methods, and that they were wasting time in groups chatting with friends instead of working" (Boaler, 2008, p. 39). Alan Schoenfeld (2004) provided a rich and detailed history of "The Math Wars" that described the conflict between those who wanted students to return to the basics of math and those who wanted to adopt the NCTM Standards. In an article published in the *Journal of Educational Policy,* Schoenfeld (2004) noted, "Epistemologically, with its focus on process, the NCTM Standards could be seen as a challenge to the 'content-oriented' view of mathematics that dominated for more than a century" (p. 268).

One possible explanation for the ardent disagreement among mathematics educators at that time could have been the public's belief in a set of unreal expectations toward educational research in general. James Hiebert (1999), professor of education at the University of Delaware, noted, "If researchers cannot prove that one course of action is *the* best one, it follows that researchers cannot prescribe a curriculum and a pedagogical approach for all students and for all time" (p. 7). Lester and William (2000) stated that "the very nature of educational activity—the complexity of the objects of study means that educational research should not be expected to be a 'science' in the traditional sense" (p. 136). That does not mean, however, that mathematics educators should abandon the practice of designing experimental studies to determine the effect of variables in increasing the success of students. Schoenfeld (1994) wrote that, while no one should be defending the way math is taught right now, "why abandon the old content specifications…until you can replace them with something that is demonstrably better"

(p. 73). As Carnine and Gersten (2000) noted, "well-controlled experimental and quasi-experimental studies are the building blocks of scientific knowledge about teaching and learning" (pp. 139-140). A focus on research was one of the guiding principles of Achieving the Dream and one of the differences from the way the NCTM Standards were developed and disseminated. The Lumina Foundation, in its creation of AtD, stressed that changes to teaching should be made only after each institution extensively studied its own data (Achieving the Dream, 2005).

Reforming mathematics education 1990-2010. In 1995, the United States Department of Education issued the first Trends in International Mathematics and Science Study (TIMSS). The report provided an analysis of how mathematics teaching in the United States differed in countries like Germany and Japan (U.S. Department of Education, 2010b). Among other things, the study found that mathematics teachers in Japan spent much more time collaborating with each other in determining how to teach a topic to students (Stigler & Hiebert, 1999). In addition, the number of topics addressed in the mathematics curriculum in Japan was far lower than a comparable U.S. classroom (TIMSS, 1995). Schmidt's 1999 phrase, "a mile wide and an inch deep" describes the method of teaching mathematics in the United States (p. 1), while counterparts in Japan learned fewer mathematical concepts but in much more depth. Stigler and Perry (1990) noted, "When visiting a Japanese mathematics class, one detects a more relaxed pace than what occurs in American classrooms" (p. 341). In Japan, the role of the teacher differs from the role generally assumed by U.S. instructors. Stigler and Hiebert (1999) described Japanese teachers as "allowing their students to invent their own procedures for solving problems" instead of merely teaching techniques as do teachers in the U.S. (p. 27).

In the 1990s, public schools used the recommendations from NCTM Standards and the TIMSS to reform their mathematics curricula. In a 1995 study on the effectiveness of school reforms, Newman and Wehlage (1995), researchers at the University of Wisconsin concluded that curriculum changes work only under certain conditions. The authors identified some important ingredients essential for school reform to be effective, including making decisions about student learning based on quality research, employing authentic pedagogy, having the organizational capacity to make substantive changes, and securing external resources (Newman & Wehlage, 1995).

From the beginning of 1999 until June of 2000, the National Research Council (NRC) commissioned a study to determine the essential elements of what mathematics students should be learning. In the report, *Adding it Up: Helping Children Learn Mathematics*, authors Kilpatrick, Swafford, and Findell (2001) posed a difficult and unresolved question: What is the definition of successful mathematics learning? Settling on the term mathematical proficiency, they described five strands that allow a student to demonstrate this mastery: 1) conceptual understanding, 2) procedural fluency, 3) strategic competence, 4) adaptive reasoning, and 5) productive disposition (Kilpatrick, et al., 2001, p. 5). Productive disposition, perhaps an unusual inclusion in a list of otherwise standard mathematical ideas, is defined as "the student's habitual inclination to see mathematics as a sensible, useful, and worthwhile subject to be learned, coupled with a belief in the value of diligent work and in one's own efficacy as a doer of mathematics" (Kilpatrick, et al., 2001, p. 107).

In 2006, the American Mathematical Association of Two-Year Colleges (AMATC) published its updated standards. AMATYC (2006) recommended that instructors teaching mathematics integrate technology, active learning, activities that promote connections between mathematics and other disciplines, multiple teaching strategies including discovery based learning and collaborative learning, and activities that allow students to experience mathematics (para. 6).

Boroch, et al., (2010) claimed, “The [AMATYC] movement to a more ‘learner-centered’ environment constitutes the most substantial reform of mathematics education over the past few decades” (p. 63).

Focused research around mathematical pedagogy, while important, does not provide answers for all the questions that arise when studying traits of successful community college students. Students must remain in school to complete a degree. Bailey and Alfonso (2005) defined four types of practices that increase persistence and completion at community colleges: 1) advising, counseling, mentoring, and orientation programs; 2) learning communities; 3) programs that address underprepared students; and 4) college-wide reform (p. 1). According to Bailey and Alfonso (2005), prior to the AtD movement, community colleges were engaged in these four areas; however, little research on community college campuses supported the effectiveness of these initiatives. Although there is no dearth of research on student learning, a great deal of this research has been (and continues to be) directed toward K-12 children. Community college students are often returning adult students who may or may not learn in the same way as K-12 students learn. The Lumina Foundation’s Achieving the Dream initiative, forced an emphasis on studying the factors that influence community college student success, prompting research that target students who place into developmental mathematics because of the high preponderance of students of color, students of poverty, and first-generation college students who often place into developmental mathematics (Achieving the Dream, 2010; Achieving the Dream, 2011a).

A focus on the individual learner. Studies over the past 20 years have increasingly focused attention on specific instructional strategies such as cooperative learning (Johnson & Johnson, 1999; Arendale, 2004; Boaler, 2008), Supplemental Instruction (Arendale, 2000; Arendale, 2004), Learning Communities (Tinto, 1997; Boylan & Saxon, 2002; Smith, et.al., 2004; Day & Frost, 2009) and educational technology (Wenglinsky, 1998; Simkins, 2002). Data on effective strategies for teaching developmental math using one or more specific instructional strategies noted above are more available than they once were. What is often missing from much of the research is the effect of those strategies for specific student populations. Grubb and Cox (2005) noted that, "our knowledge of students and their attitudes toward learning is sorely lacking, partly because empirical analyses of teaching usually focus on instructors rather than on students" (p. 95). Smith, et al., (2004), explain:

> The relationship between pedagogy and content is complicated, and many of our ideas and practices are unexamined and based on misconceptions. Understanding how people learn, what effective learning environments look like, how modern technologies might have an impact on learning, and how all of this shapes the instructional role is a great challenge that requires rethinking how we train and support our teachers and construct our learning environments. (p. 13)

Lesson Study, an idea birthed in Japan, is one initiative gaining momentum in the U.S. Makoto Yoshida coined the phrase "Lesson Study" by translating the original term (*Jugyokenkyu*) into English while working on his doctoral dissertation (College Lesson Study, 2011, para. 1). Rather than focusing on the behavior of teachers, Lesson Study compels teachers to focus on learners. Teachers using the Lesson Study approach work collaboratively to develop a script for the day's lesson. One teacher delivers the information using the prepared script and the other teachers observe the students in the classroom. The observers note the times during the lesson in which a student grasped material and the times when a student became confused. The teachers then work collaboratively to restructure the lesson and re-write the script. The University of Wisconsin at La Crosse was one of the first institutions in the U.S. to adopt the Lesson Study approach in higher education. Cerbin and Kopp (2011), two professors at the university, explain their approach as "a teaching improvement activity, in which instructors jointly develop, teach, observe, analyze, and revise lessons for their courses" (p. 1).

Other recent research into mathematical learning has moved from studying the transfer of information from teacher to learner to creating contexts that make learning possible (Prosser & Trigwell, 2010). Current educational psychologists argue that within those learning contexts, researchers need to become more aware of who the individual is and not just what the individual is learning (Becker, Krodel, & Tucker, 2009). Many of the studies reported to Achieving the Dream contain data disaggregated among gender, ethnicity, and socio-economic level (Achieving the Dream, 2010). Community Colleges participating in the Achieving the Dream initiative continue to explore other questions:

What are the similarities and differences of university students when compared to community college students? What impact does the student's upbringing play in the success of that student in college? How does the placement of a student, especially in the area of mathematics, determine the success or failure of that student? In spite of recent research in these areas, we know very little about the factors that either promote success or create roadblocks to success for students enrolled in community colleges who test into developmental courses (Grubb & Cox, 2005). It is difficult if not impossible to test hypotheses about the components of teaching that most influence learning, especially when student characteristics are taken into account (English & Halford, 1995; Kilpatrick et al., 2001; Hiebert, et al., 2005).

Colleges increasingly recognize the importance of studying characteristics of students entering community colleges who need remediation. However, there is a difference between identifying factors that either impede or promote success and actually increasing the success of those underprepared students. Several studies suggest remedial instruction may not be effective, especially for at-risk student populations (Tinto, 1998; Levin & Calcagno, 2008; Bettinger & Long, 2009; Roksa & Calcagno, 2008). In a study of first-time college students in community colleges in Florida, Roksa and Calcagno (2008) found that, "Even when academically unprepared students complete the most demanding intermediate outcome (the Associate of Arts degree), they continue to lag behind their academically prepared peers in transfer to four-year institutions" (p. 262).

Despite the claims of detractors, a significant number of studies provide evidence of the effectiveness of programs targeted toward underprepared students. Calcagno and Long (2008) found remediation increased the likelihood that students would enroll in the subsequent fall term but made no difference in their chances of passing college-level courses, in completing associate degrees, or of transferring to a four-year school (p. 22). Bettinger and Long (2009) studied 23,000 students at public universities in Ohio and found remedial courses were effective: students had better outcomes, including better levels of retention and degree completion. However, remediation is costly: “More than $1 billion annually for public colleges alone” (Bettinger & Long, 2009, p. 737). Thus, “While community colleges can serve as a democratizing force, their ability to overcome the poor academic preparation with which some students enter higher education is limited” (Roksa & Calcagno, 2008, p. 5).

Many of the over 100 schools taking part in AtD are researching what factors influence success among students who test into some of the lowest developmental mathematics courses. In California community colleges, course success rates in developmental math classes have consistently been around 54% (Boroch, et al., 2010). In a study of 28 exemplary community colleges’ developmental education programs, all but one of the colleges indicated that when their college determined institutional priorities, the college rated developmental education as “completely” or “extensively” important (Boylan & Saxon, 2002). In a study of students enrolled in developmental education classes in Texas colleges, Boroch, et al. (2010) found that schools with the highest student retention rates were located in institutions that considered developmental education a priority (p. 15). Often, however, many of the students testing into developmental education classes are students of color, students of poverty, and first-generation college students. As Becker, et al. (2009) note, those students are often the ones who do not persist at college because they do not know the hidden rules of higher education.

The support for cooperative and active learning. David Arendale, in a 2004 review of literature surrounding the effectiveness of cooperative learning, concluded:

> The professional literature is filled with reports of individual professors integrating this approach [cooperative learning] into postsecondary classrooms in diverse ways. Increased attention has been placed on this practice due to claims by some programs that carefully coordinated and managed learning programs with specific protocols can increase student persistence rates towards graduation, supporting both student goal aspirations as well as bolstering institutional revenues. (p. 2)

In that same article, Arendale (2004) described the six types of cooperative learning activities that meet his pedagogical criteria, which included evidence of effectiveness and evidence of replication at another site: Accelerated Learning Groups (ALGs), Emerging Scholars Program (ESP), Peer-Led Team Learning (PLTL), Structured Learning Assistance (SLA), Supplemental Instruction (SI), and Video-based Supplemental Instruction (VSI) (p. 2). All six strategies fall under the category of cooperative learning and all have components sufficient for study in higher education settings (Arendale, 2004).

The University of Minnesota (2002) website described Roger and David W. Johnson as "the nation's leading researchers on cooperative learning" (para. 1). The two brothers, both professors at the University of Minnesota, performed over 80 research studies and reviewed over 800 other studies on the topic of cooperative learning

(University of Minnesota, 2002). The Johnsons believed that cooperative activities, when correctly constructed can lead to numerous positive outcomes including

- Positive interdependence (each individual depends on and is accountable to the others—a built-in incentive to help, accept help, and root for others)
- Individual accountability (each person in the group learns the material)
- Promotive [*sic*] interaction (group members help one another, share information, offer clarifying explanations)
- Social skills (leadership, communication)
- Group processing (assessing how effectively they are working with one another) (Johnson, Johnson, & Smith, 1991a, p. 3:16)

Johnson and Johnson (1988) claimed that research on how students perceive and interact with one another in cooperative learning activities has been neglected, noting:

> …some time is spent on how teachers should interact with students, but how students should interact with one another is relatively ignored. It shouldn't be. How teachers structure student-student interaction patterns will have a lot to say about how well the students learn, how they feel about school and the teacher or professor, how they feel about each other, and their self-esteem. (para. 1)

The Johnson brothers described the types of interactions that can occur between students. Students can *compete* to see who is "best"; they can work *individualistically* on their own toward a goal without paying attention to other students; or they can work *cooperatively* with a vested interest in each other's learning as well as their own (Johnson & Johnson, 1988, para. 2).

Millis and Cottell (1998), in *Cooperative Learning for Higher Education Faculty*, explained that cooperative learning has an underlying philosophy of "respect for students of all backgrounds and a belief in their potential for academic success" (p. 5). Moreover, cooperative learning theorists believe that learning is inherently social (Millis & Cottell, 1998). Johnson, Johnson, and Smith (1991b), professors at the University of Minnesota, described the positive effects cooperative learning can have on student success: "As relationships within the class or college become more positive, absenteeism decreases and students' commitment to learning…willingness to take on difficult tasks…and productivity and achievement can be expected to increase" (p. 44). Johnson and Johnson (1999) described the differences between pseudo-group work, where students are "assigned to work together but have no interest in doing so" and cooperative group work, where "students work together to accomplish shared goals" (p. 3). This social network is especially important for students at community colleges, who are primarily part-time and who may not feel connected to the college (Center for Community College Student Engagement, 2008, p. 2). Bean and Metzner (1985) studied attrition for nontraditional students, both at four- and two-year institutions, recommending that institutions "focus first on building student involvement in the classroom through activities such as learning communities" (p. 502). The authors noted that the classroom is the place where commuter students have the most contact with the college and with individual faculty members (Bean & Metzner, 1985). Millis and Cottell (1998) agreed that, "everyone in a well-conducted cooperative-learning classroom has an opportunity for equal participation and equal validation" (p. 11).

A review of research into student learning when incorporating cooperative learning activities yields both the positive and negative outcomes that can occur. Leikin and Zaslovsky (1997) found that by implementing cooperative learning activities in classrooms in Israel, "there was an increase in students' mathematical communications and interactions" (p. 352). The researchers also noted that while these cooperative learning opportunities promoted learning, "the use of open-ended tasks that require more creativity would lead to even better results" (Leikin & Zaslovsky, 1997, p. 352). Lubiensky (2000) wrote that some students reacted negatively to cooperative learning activities involving critical thinking, commenting, "I used to do really good in math but here I don't understand it" (p. 463). Part of the difficulty in measuring the effectiveness of cooperative learning activities may be because students begin to view mathematics differently, which may stretch the students' assessment of their own learning. As Devlin (2000) wrote, many people hold a number of myths about mathematicians that are not true, including the ability of mathematicians to perform arithmetic operations in their heads and follow a set of rules. Devlin (2000) provided this definition of what mathematics truly means: "Mathematics is the science of order, patterns, structure, and logical relationships" (p. 74). How many students, if asked, would define mathematics in that way? Additional research should focus not only on increased mathematical learning but also on the ability of cooperative learning activities to expand a student's notion of the nature of mathematics. Ladson-Billings (1997) summarized the mathematics reform movement by explaining the need to require students to "not merely memorize formulas and rules and apply procedures but rather to engage in the *processes* of mathematical thinking" (p. 697).

A focus on the process of mathematical thinking, rather than merely on skills, can happen effectively when students work in small groups. Boylan and Saxon (as cited in Boroch, et al., 2010) noted that group learning is especially effective for adult students, explaining:

> Whatever they are called, active learning methods are characterized by the fact that they are designed to elicit students' active participation in the learning process. Such involvement is critical for adult students because these students have already been exposed to the typical lecture, discussion, drill and practice approaches used in high school courses and college remediation and they have not worked. (p. 71)

In spite of the existing researching supporting the use of cooperative learning activities in higher education, implementing this kind of instructional strategy is not so easy. Weinstein and Meyer (1991) wrote that although an active learning approach is appealing to instructors, "Applying the approach is more difficult, because instructors must give up the illusion of control. That change shakes the foundation of content as the primary focus of our teaching" (p. 36). Boroch, et al. (2010) believe one way instructors can give up control is by focusing on student learning rather than on the delivery, noting "the most important role of the instructor is the design of the instructional experience in order to provide structure and goals, even if he or she relinquishes control" (p. 71). Not only do active learning strategies increase student learning, they may also increase retention. Kuh, Kinzie, Cruce, Shoup, and Gonyea, (2006) found that students who engage in educationally purposeful activities are more likely to persist in college.

Intervention strategies in higher education since 1970: A re-focus on developmental education. In the early 1970s, colleges began to pay particular attention to the challenges faced by students in developmental classes. This era ushered the establishment of Learning Assistance Centers (LACs), whose primary purpose was to increase the success of underprepared students (Arendale, 2000; Flippo & Caverly, 2000). Frank Christ at California State University-Long Beach is generally credited with creating the Learning Center concept, providing students with a centralized location where they received extra help with developmental reading, writing, and mathematics (Enright, 1975; Arendale, 2000). By the mid-1980s, a consortium of colleges created standards and guidelines for how learning centers should operate. Although some colleges simply refused to teach developmental courses, expecting students who needed remediation to enroll in the local community colleges, other colleges embraced their roles in helping underprepared students succeed. For community colleges, the creation of developmental courses or LACs fell in line with their mission.

Most community colleges established learning assistance centers to help students who placed into developmental courses (Perin, 2004, p. 2). In establishing these centers, some community colleges opted for a centralized approach; others opted for a non-centralized coordinated approach (Perin, 2004). The mission of these learning centers today supports the definition by Christ in 1971: "A LAC is a facility where students (learners) come to effect change in their learning assistance skills and attitudes, particularly in areas of reading, writing, computation, and study skills" (para. 5). For example, in 2010, the Math Resource Center at JCCC served over half of the students enrolled in math courses at the college and logged over 32,000 student hours each semester (Johnson County Community College, 2011f).

Summary of the history. Learning theorists and educators committed to improving learner outcomes have continued to search for effective pedagogical strategies. Mathematics education approaches have moved from an emphasis on drill and skill, to a focus on teaching foundational concepts, to one that incorporates real-world applications. Community colleges, while continuing to fulfill their role as providers of developmental math education, recognize the importance of aligning institutional resources with strategies that will influence learning for their unique student populations.

Promising Practices in Mathematics

While establishing learning centers is an excellent way to provide additional help for students outside of class, it does not address the way in which mathematics teachers deliver material in the classroom. Underprepared students entering community colleges experienced elementary and secondary math classes. For whatever reason, the students did not learn the material in those classes. Stigler, Givvin, and Thompson (2010), explaining why many community college math students struggle, wrote,

> Students who failed to learn how to divide fractions in elementary school, and who also probably did not benefit from attempts to re-teach the algorithm in middle and high school, are basically presented the same material in the same way yet again. It should be no surprise that the methods that failed to work the first time also don't work in community college. And yet that is the best we have been able to do thus far. (pp. 2-3).

Rather than doing the same thing again and expecting different results, colleges must focus on ways to teach differently. Before attempting a serious effort at pedagogical reform, educators must pay attention to what the literature says about effective teaching practices. Research conducted by Levin and Koski (1998) found the following components to be effective when designing intervention programs for students in higher education.

- Motivation: building on the interests and goals of the students and providing successful interventions for underprepared students
- Substance: building skills within a real-world context instead of an abstract approach
- Inquiry: developing students' inquiry and research skills
- Independence: avoiding a completely structured curriculum and instead allowing students to self-determine which areas they want to spend additional time learning
- Multiple approaches: rather than the one-size-fits-all approach to teaching, providing opportunities for students to learn from a variety of sources (p. 16)

Stigler et al., (2010) reinforce these components when they write: "students who have failed to learn mathematics in a deep and lasting way up to this point might be able to do so if we can convince them, first, that mathematics makes sense, and then provide them with the tools and opportunities to think and reason" (p. 3). The next section of this chapter provides an examination of some of the specific intervention strategies implemented in colleges since the 1970s and their effect on learning.

Project-based learning. In the early 1990s, Jo Boaler, Stanford University professor, began researching students' abilities to apply mathematics to their lives. Boaler (1998) found that "the act of using mathematical procedures within authentic activities allowed the students to view the [mathematical] procedures as tools they could use and adapt" (p. 59). Boaler's work led her to create a new category of mathematical instruction, Project Based Learning (PBL). In her 2008 book, *What's math got to do with it*, Boaler described the impact of project-based learning on students, especially traditionally underserved math students, including minority students and females. Boaler conducted a longitudinal study of two equivalent schools in the U.K. One of the schools taught math using a traditional method (instructor demonstrates and students practice); the other school used a discovery-based project approach where students learned math through authentic applications. Boaler (2008) found that, by their senior year, "a staggering 41% of the students at the project-based school were in advanced classes of pre-calculus and calculus, compared with 23% of students from the traditional classes" (p. 66). In her work with California High Schools, Boaler found that "three times as many students at the project-based school received the top grade achievable on the national examination in math" (Edutopia Staff, 2010, p. 1).

While Boaler's work focused exclusively on students in a K-12 setting, two professors at Duke University studied the positive effects of project-based learning on college students. Moore and Smith (1992) created Project CALC (PC) in 1989 to find ways to get more students successfully through the calculus sequence at Duke University. The essential elements of PC methodology are the use of real-world problems, hands-on learning, teamwork, and a significant writing component. In 1994, Jack Bookman, Duke

University professor, and Charles Friedman, professor at the University of Pittsburgh, conducted a research study to evaluate the effectiveness of PC. The researchers examined students at Duke who had taken calculus through the PC approach and compared them with students in a traditional classroom setting. The researchers found that, although students in the PC classes complained that the material was "too vague and complicated," data showed that retention, attitudes, and learning were all significantly more positive for the PC class when compared to the traditional class (Bookman & Friedman, 2005).

While innovative instructors can provide the genesis for new pedagogy, advances in technology can also drive pedagogical improvements. In a 1998 report, researchers noted that, "Three-fourths of the teachers who participated in a survey reported that project-based instruction had increased since the introduction of laptops in their classrooms" (Rockman, Chessler, & Walker, 1998, p. ix). Wenglinsky (1998) found that if used merely for drill or practice, computers typically had a negative effect on student achievement; however, if students used computers for real-world applications, such as spreadsheets, or to simulate relationships or changing variables, student achievement increased (pp. 3-4). Among the many reported benefits of using computers to support project-based learning were greater student engagement, improved analytic abilities, and a greater likelihood to apply high-order thinking skills (Rockman, et al., 1998, pp. xiii-xiv). In a review of literature, Stites (1998) found that project based learning was "especially effective when supported by educational technology," noting that using technology had a profound impact in a school district where students were predominantly low-income students (p. 1). The Challenge 2000 Multi-Media project, in studying the role technology played to support project-based learning, reported that "low-achieving students benefitted most from the project-based multimedia approach" (Simkins, 2002, para. 9). Calling their initiative, *Authentic Learning with Technology*, Rockman et.al (1998) defined their contribution to student learning this way:

> Authentic learning is an approach to teaching and learning that has students working on realistic problems, to gain new knowledge and skills in context, rather than listening to lectures and memorizing vast amounts of information to be reproduced on tests. Students construct their own meanings from their work and produce products and performances that have value or meaning beyond success in school. It is real work for a real audience (p. 1).

Proponents of project-based learning garner support from the research on constructivist theory. As Skrtic, Harris, and Shriner (2005) noted, "Constructivist approaches are concerned with actively engaging students in dialogues about the concepts being discussed" (p. 337). The authors continued:

> …students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts (e.g., a model, a report, videotape, or computer program). (p. 371)

Several studies indicated that students in a project-based mathematics class may not experience immediate results. Wood & Sellers (1997) found that, "Being in a problem-centered mathematics program for 2 years is significantly better than being in either 1 year of a problem-centered program or all textbook instruction" (p. 181). A longitudinal study by two professors at the University of Tennessee and one from the University of Memphis found that K-12 schools using project-based learning in mathematics outperformed the control schools, though not in the first year (Ross, Sanders, & Wright, 2000). Although the results of the four-year longitudinal study were not as significant as the researchers had hoped, the researchers noted that the experimental group (i.e. project-based) was highly diverse and relatively disadvantaged (Ross, et.al, 2000).

Boaler (1998) argued that not only does project-based teaching differ from traditional teaching in terms of improved test scores; students learn different things in a project-based setting. Studying behaviors such as the ability to follow rules and the ability to react to a cue, Boaler found that students in a traditional math class were more likely to try to do what was expected of them rather than think creatively about how to solve a problem. Boaler summarized her 1998 research with the following conclusion: "a traditional textbook approach that emphasizes computation, rules, and procedures, at the expense of depth of understanding, is disadvantageous to students, primarily because it encourages learning that is inflexible, school-bound and of limited use" (p. 60).

Supplemental instruction. In 1973, David Arendale, professor of education at the University of Missouri-Kansas City, worked with doctoral candidate Deanna Martin to create the Supplemental Instruction (SI) model (Arendale, 2000). According to Arendale (2000), "SI provides regularly scheduled, out-of-class, peer-facilitated sessions that offer students an opportunity to discuss and process course information" (p. 10). Unlike Learning Assistance Centers (LACs), the SI model did not utilize a central resource center approach, opting instead for a course-specific strategic model. The SI model employed students who recently completed the course to serve as facilitators for extra study sessions. Those peer mentors attended class and facilitated the SI session, helping students learn study skills along with course content (Arendale, 2000).

Many colleges and universities in the U.S. and beyond adopted the SI model and conducted studies showing the effect of the instruction, to participating students (Kenney, 1989; Fisher, 1997; Jarvi, 1998; Lazari & Simons, 2003) and facilitators (Ashwin, 1993; Metcalf, 1996). One of the distinguishing factors of SI courses is that the sessions are intended for all students, targeting high-risk courses rather than high-risk students. At the same time, the sessions are not mandatory. Students decide whether or not to attend. Arendale (2000) wrote, "SI avoids the stereotype threat by offering a service to all students in the class rather than attempting to predict which students will need to attend" (p. 14). While institutions have generally created SI sessions for non-developmental courses, a few studies have noted the effectiveness of SI within developmental courses (Stephens, 1995; Zachry & Schneider, 2008).

Peer-led team learning (PLTL). The Peer-Team Learning Workshop Model (PLTL), developed at the City College of New York, involved "all students in their own learning, thus increasing their comprehension, problem-solving skills, and ability to work on teams" (Gafney & Varma-Nelson, 2008, p. 87). The PLTL concept uses some of the same characteristics of the Supplemental Instruction model (i.e., student mentors who have previously taken the course) and provides opportunities for these mentors to be in a leadership role (Gosser, et al., 2001). Unlike Supplemental Instruction, PLTL activities incorporate mathematical projects for small group collaboration, rather than utilizing the session time to work homework problems (Gosser, et al., 2008, p. 11). Also unlike

Supplemental Instruction, the student mentors do not attend the regular class and "have little connection to students' classes and instructors" (Zachry & Schneider, 2008, p. 35). The PLTL workshop model engages teams of students in learning sciences, mathematics, and other undergraduate disciplines guided by a peer leader (Gafney & Varma-Nelson, 2008). The PLTL website, in describing the characteristics of the workshops, states that the sessions provide active learning for students, give undergraduates an opportunity to be in leadership roles, and engage faculty in new dimensions of instruction (PLTL, 2011).

Learning communities. Educators working collaboratively to analyze student data and use those data to determine necessary pedagogical changes, occur in both K-12 and higher education institutions. Called Professional Learning Communities (PLCs) in the K-12 setting, movement, leaders Richard and Rebecca DuFour and Robert Eaker (2008), defined PLCs as, "collaborative teams whose members work *interdependently* (authors' emphasis) to achieve *common* goals—goals linked to the purpose of learning for all—for which members are held *mutually accountable"* (p. 15). Within that definition are several assumptions. First, individual instructors are in fact giving up some of their classroom control. Instructors no longer work independently; each instructor uses opportunities to find what elements of his or her own instruction need to change in order to improve student learning. Second, instructors jointly determine the common learning goals. While districts, principals, or curriculum specialists may have imposed a similar requirement in the past, the creators of PLCs expected that teachers work collaboratively to help establish these common goals. Third, the expectation that all instructors will be mutually accountable for the achievement of these common goals raised the bar on assessment, making it something that all educators needed to consider (DuFour, DuFour, & Eaker, 2008).

In higher education, a concerted effort to implement the concept of learning communities into the college curriculum began at roughly the same time. The college learning community movement began at The Evergreen State College in Olympia Washington in the mid-1980s (Fogarty, et al., 2003). College learning communities had their own set of leaders including K. Patricia Cross, Jean MacGregor, and Vincent Tinto (MacGregor, 1994; Washington Center, 2011). However, those leaders were much less prescriptive in their writing about what should or should not happen within a learning community. In a 1998 speech, Tinto defined learning communities as “a kind of co-registration or block scheduling that enables students to take courses together. The same students register for two or more courses, forming a sort of study team” (para. 3). According to Fogarty, et al. (2003), the term learning communities refers to, “the purposeful restructuring of the curriculum by linking or clustering courses that enroll a common cohort of students” (p. 5). Smith, et al. (2004) expanded on this definition by adding that learning communities, “build community, enhance learning, and foster connections among students, faculty, and disciplines” (p. 20). Arendale (2004) noted that “In addition to often employing some version of student interactive learning, learning communities take several approaches to modifying the classroom experience by restructuring the curriculum” (p. 3). Those approaches include: 1) Integrated seminars of student cohorts in which students participate in an experience not directed by faculty members; 2) Linked courses, typically two or more courses joined thematically; and 3)

Coordinated study, courses team-taught by two or more faculty (Smith, et al., 2004, pp. 72-77).

In 1996, the National Learning Communities Consortium, also founded at Evergreen Community College, established a yearly conference highlighting the best practices of colleges using learning communities. That conference has now passed its fifteenth year (Kennesaw, 2009). The purpose of joining two or more courses in establishing Learning Communities, according to MacGregor, Tinto, and Lindblad (2001), was to, “Deepen learning, create a deeper sense of connection among ideas and curricular issues, and create a deeper sense of community” (p. 1). Inherent in the definition of the higher education version of Learning Communities is that students can learn both (or all) subjects more deeply when instructors combine those disciplines in a way that makes them more meaningful (Day & Frost, 2009). Although not stated directly in the higher education definition, the three elements delineated in the work by DuFour et al., (2008) must be present: professors involved must work interdependently, common goals must be established, and the professors are mutually accountable for their students’ learning.

Colleges apply a different definition of learning communities from the one applied in K-12 settings, primarily because of cultural differences. The K-12 system, with a reliance on district leadership, can provide much greater centralized oversight. The college culture, with its insistence on academic freedom, must instead rely on individuals who believe collaboration will provide deeper learning for their students. Colleges and universities, especially community colleges, continue to expand Learning Communities into the culture (Arendale, 2004). One way colleges work around the academic freedom barrier is to combine two or more different disciplines into a learning community, rather than expecting professors within the same discipline to collaborate. That concept is not a new one. The actual introduction of this type of learning community dates back to the early twentieth century. Smith (2001) opined that Alexander Meiklejohn was most likely the first to introduce learning communities where several disciplines were combined into a single course. Meiklejohn defined his learning communities as "interdisciplinary and team-taught…The pedagogy stressed active learning and the teachers were seen as advisors and facilitators" (as cited in Day & Frost, 2009, p. 95). Meiklejohn's attempt at creating a new learning model lasted about five years. Other attempts to create these types of learning communities emerged in the 1960s. These also only lasted a short time. It was not until the 1980s when Evergreen College embedded learning communities into its curriculum that college learning communities began to flourish. According to a recent article by Day and Frost (2009), today "over 400 colleges and universities in the United States have well-developed [Learning Community] programs" (p. 95).

Proponents of learning communities combined several essential elements of cooperative learning, as defined by Johnson and Johnson (1988). Those elements include positive interdependence (each individual depends on and is accountable to the others), individual accountability (each person in the group learns the material), and intentional interaction (group members help one another, share information, and offer clarifying explanations) (Johnson & Johnson, 1988, para. 7). At the same time students learn the material, they develop social skills (leadership, communication) through the structured activities.

Boroch, et al. (2010) provided the most comprehensive study on the effectiveness of learning communities in higher education to date. The authors concluded that:

> …existing research provides the most support for learning communities. The positive effects of learning communities on persistence and graduation are consistent with the most influential theoretical perspectives used to study retention, and empirical research suggests positive effects. Thus learning communities offer an approach to connecting more intensively with community college students, who often spend little time on campus outside of classes. One important area for future research involves investigation of learning communities for part- time, nontraditional students. (p. 23)

Recent community college interventions. The Lumina Foundation for Education, through its network of Achieving the Dream colleges, created a climate that fosters educational innovation (Zachry & Coghlan, 2010). To help accomplish its stated goal that the percentage of graduates with a high-quality college degree or certificate will increase to 60% by the year 2025, the Lumina Foundation provided substantial resources to support colleges willing to experiment with new initiatives (see chapter one). Responding to results of research conducted by other AtD schools, colleges around the nation created their own innovative programs, many in developmental mathematics or in the gateway mathematics course, College Algebra. Mathematics educators use research to help define successful strategies for increasing student success and student persistence, including: a) Making student success in developmental education an institution-wide commitment; b) Establishing a goal to ensure that students who come under-prepared for college-level work are able to succeed at rates at least as high as those who came fully prepared; c) Carefully coordinating the various units involved in the delivery of developmental courses; d) Carefully selecting the faculty and staff who will work with developmental students; and e) Providing professional development for all faculty and staff who work with under-prepared students (Boroch, et al., 2010, pp. 15-29).

Four leaders in designing innovative programs to help students succeed in developmental math are Guilford Technical Community College in North Carolina, Mountain Empire Community College in Virginia, Patrick Henry Community College in Virginia, and Valencia Community College in Florida. Each college has taken a different path to create meaningful opportunities for students to succeed (Zachry & Schneider, 2008; Zachry & Coghlan, 2010). The colleges, using research to guide them, developed initiatives that targeted their individual student populations. The differences between each are notable.

Guilford Tech created a "transitions" program for students who tested into the lowest-level developmental reading, writing, and math courses. The college administers the transitions program in an intensive five-day-a-week format with students meeting together five hours each day in a Learning Community environment. The course is taught by two instructors who work together to develop activities that reinforce the teaching of reading, writing, and numerical skills. One important aspect of the transition program, supported through a state adult education grant, allows students to attend the transition program without depleting their financial aid resources (Zachry & Schneider, 2008).

After studying college data, researchers at Mountain Empire Community College realized that many of the students who needed remediation could benefit from a refresher, rather than an entire developmental course. The college determined that the most beneficial program for students would be one that "truncated" the developmental math sequence, allowing students to proceed faster through the courses. Mountain Empire developed two programs: a Fast-Track program, designed to allow students to move through the developmental math sequence in one semester, and a program that joined a traditional class with a supplemental learning session. The college designed its supplemental learning sessions using a Peer-Led Team Learning (PLTL) model (Gafney & Varma-Nelson, 2008). Students, who enrolled in one of the PTLT classes at Mountain Empire, attended a regular five-hour class as well as an additional hour of project time. Students did not pay for the sixth hour (Mountain Empire Community College, 2011).

Patrick Henry Community College researchers studied their students and determined three critical barriers to student success: student engagement, workforce skills, and persistence (Achieving the Dream, 2010). Using elements of Johnson and Johnson's (1988) Cooperative Learning Model, Patrick Henry College revamped math classes to move from a traditional lecture model to one that engaged students through dedicated group activities. By restructuring classes in this manner, the college believes "they have addressed student engagement, workforce skills, and persistence" (Zachry & Schneider, 2008, p. 43).

Valencia Community College in Florida created a three-step approach to addressing the needs of its unsuccessful students. According to Julie Phelps, project director of Achieving the Dream at Valencia, the college first instituted Supplemental Learning activities for developmental math courses (pre-algebra, elementary algebra, and intermediate algebra) (J. Phelps, personal communication, October 2010). The second phase introduced learning communities, mostly joining a developmental math class with a study-skills class. The third phase required students who tested into developmental reading, writing, and math to enroll in a Life Skills course (Valencia Community College, 2010). For the three pre-college level math courses, Valencia used a supplemental learning model, hiring successful students as peer mentors; those students attended classes and offered voluntary review sessions (J. Phelps, personal communication, October 2010). Recognizing success with this initiative, especially in the achievement of minority students, the college implemented more classes with supplemental learning sessions (J. Phelps, personal communication, October 2010). From spring 2006 through spring 2009, 671 course sections had supplemental learning leaders, affecting 16,135 students (Valencia Community College, 2010). In 2008-09, 5,940 students were in a supplemental learning section of the targeted courses, comprising 13.9% of the total course enrollment (Valencia Community College, 2010). As of October 2010, 23% of students at Valencia were enrolled in a supplemental learning section for developmental mathematics (J. Phelps, personal communication, October 2010).

Although the approaches differ, all four colleges provided data demonstrating increased student success after the implementation of their initiatives (Achieving the Dream, 2010). Each college's intervention strategy worked, complimenting the resources available and targeting the population at hand.

Summary of Literature Review

Community colleges, recognizing that their student population differs from other college populations, have begun to study success rates, noting the unique challenges their students face. Like the students they serve, these colleges have their challenges, which include developing innovative programs for students who arrive at their doors unprepared for college-level work, while, at the same time colleges must deal with significantly reduced funding. Model colleges, using what they have learned about successful pedagogical strategies and characteristics of their unique student populations, have implemented innovative strategies to improve persistence and increase student success. As more information about successful strategies becomes available, other colleges are implementing strategies to try to increase success among their unique student populations. Using demographic data along with research on effective practice, Johnson County Community College decided to initiate peer-led supplemental project-based instruction sessions to improve persistence and success in their College Algebra classes. In chapter three, the methodology of the study to determine the effect of that strategy is presented.

Chapter Three

Methods

This mixed-method study determined the effect of peer-led supplemental project-based instruction sessions for students (n = 243) enrolled in a College Algebra course at a community college. This chapter covers the design, population, selection of participants, instrumentation, data collection and data analysis procedures, validity and reliability, and limitations for the study.

Research Design

This quasi-experimental study employed a mixed-methods design, with a higher weight given to the quantitative data (Creswell, 2009), to compare the treatment group (peer-led supplemental project-based class) and the control group (traditionally taught class). Lunenburg and Irby (2008) explain the characteristics and the limitations of quasi-experimental design: "Even though the best causal research is reflected in true experimental designs, most research in education that requires causal inferences cannot be conducted under true experimentation due to the inability to randomly assign participants to experimental or control groups" (p. 49).

The design of the quantitative portion of the study afforded examination of the relationship between supplemental mathematical projects led by peer-tutors (independent variable) to increase persistence (dependent variable), improve performance in the class and on the departmental final exam (dependent variables), and change in attitude toward mathematics (dependent variable). Qualitative data, including student postings to a learning management system, open-ended interviews, and subsequent structured interviews, determined stakeholders' perception of student success in mathematics courses because of their experiences with peer-led supplemental project-based instruction sessions. The mixed-method design provided the opportunity to “expand on the findings of one method with another method” (Creswell, 2009, p. 14). Quantitative data from a large number of individuals preceded interviews with a few participants to, “obtain their specific language and voices about the topic” (Creswell, 2009, p. 19).

To determine the effect of peer-led supplemental project-based instruction sessions on persistence, successful completion of the course, and understanding of course concepts, participating instructors tracked the number of days students persisted in the course, administered a common final exam, and calculated final grades earned by students. Lunenburg and Irby (2008) define such a study as “a posttest-only design with nonequivalent comparison groups” (p. 50). To determine the effect of peer-led supplemental project-based instruction sessions on student attitudes toward mathematics, participating instructors administered a pre- and post-attitudinal survey.

A phenomenological approach to conducting interviews and reviewing documents (Lunenburg & Irby, 2008, p. 90) allowed the researcher to analyze responses for themes and “perspectives on central issues” (Patton, 1990 as cited in Lunenburg & Irby, 2008, p. 94). The rationale for including a qualitative component to this study was twofold: 1) to identify whether the use of project-based, supplemental instruction sessions led to improved student attitudes toward mathematics; and 2) to discover factors of project-based supplemental instructional components that enhanced student success or impeded student success.

Population

Participants consisted of students (N = 2,188) enrolled in a College Algebra class at Johnson County Community College (JCCC) during the fall 2010 or spring 2011 semester; instructors (N = 16) teaching multiple sections of College Algebra in the same format (i.e., two-days-a-week or three-days-a-week); and tutors (N = 22) on staff in the Math Resource Center (MRC). This college was chosen because of the researcher's ability to gather and analyze student data.

Sampling

Instructors and classes. While JCCC offers College Algebra in a variety of teaching modalities—both in a face-to-face format and through distance learning—students in distance learning (online) classes were not included in the study because of the required supplemental instruction sessions. From all possible instructors teaching multiple sections of College Algebra in the same format (N = 10), two instructors volunteered to participate in the study during fall 2010; three instructors volunteered to participate in the spring of 2011.

The college offers face-to-face College Algebra classes in a one-day-a-week format, two-day-a-week format, three-day-a-week format, or a five-day-a-week slow-paced format. Every attempt was made to include as many formats in the study as possible. Table 1 below describes the format of the classes included in the study.

Table 1

Format of Classes Participating in the Study

Instructor	Semester	Number of Weekly Meetings
A	Fall 2010	3
B	Fall 2010	2
C	Spring 2011	5
D	Spring 2011	2
E	Spring 2011	3

The five instructors who volunteered to participate taught two sections of College Algebra during the same semester in the same format. Once identified, those instructors randomly selected one section as experimental, which included peer-led supplemental project-based sessions, and the other class as a control group, which did not include peer-led supplemental project-based sessions. The experimental classes taught in a two-day-a-week format or a three-day-a-week format (Instructors A, B, D, and E) had an additional hour of class scheduled. Students enrolling for one of those experimental classes knew they were committing to an additional hour of instruction. The experimental class taught in a five-day-a-week format (Instructor C) did not include an extra hour of instruction; for that class only, supplemental projects were nested within the course material.

Students. All College Algebra classes chosen for participation in the study required no special permission for enrollment. Therefore, students self-selected either one of the experimental classes or one of the control classes. All classes chosen for study had a maximum enrollment of 30 students. Table 2, shown below, gives class sizes on the twentieth day of class for each of the experimental and control classes participating in the study.

Table 2

Twentieth Day Class Sizes of Participating Classes

Section	**Semester**	**20th Day Class Size**
Experimental A	Fall 2010	25
Control A	Fall 2010	25
Experimental B	Fall 2010	24
Control B	Fall 2010	28
Experimental C	Spring 2011	26
Control C	Spring 2011	22
Experimental D	Spring 2011	22
Control D	Spring 2011	25
Experimental E	Spring 2011	19
Control E	Spring 2011	27

Note. From Johnson County Community College Attendance Reports, 2011e.

Unlike the relatively large stratified sample chosen for the quantitative portion of the study, the subsample for the qualitative portion was smaller and more purposefully selected. As Creswell (2009) explains, "the idea behind qualitative research is to **purposefully select** (author's emphasis) participants or sites that will best help the researcher understand the problem and the research question" (p. 178). A purposive sample of students (n = 3) from different demographic backgrounds agreed to take part in interviews; two successfully completed College Algebra and one did not successfully complete.

Tutors. Two purposively selected peer tutors from those employed in the Math Resource Center (MRC) facilitated the supplemental sessions. In addition to serving as project session facilitators, the tutors chosen to participate in the study worked approximately 20 hours a week in the MRC. The tutor and instructor met prior to the beginning of the semester to foster a positive working relationship.

Instrumentation

Supplemental sessions and materials. Materials for the supplemental sessions were created using a combination of cooperative learning strategies, which included components of project-based mathematics (Boaler, 1998), Supplemental Instruction (Arendale, 2000), learning communities (MacGregor, 1994; Tinto, 1998; Day & Frost, 2009), and Peer-Led Team Learning (Gosser, D., et al., 2001). Students in one of the experimental College Algebra classes met an additional hour each week to work on structured projects. Students who opted for one of the experimental classes knew they were signing up for this additional hour of class. Table 3 below shows the way in which one experimental class appeared on the college's website.

Table 3

Course Listing of One Experimental Section

Division	Course	Section	Days	Time	Classroom
Math	171	009	MWF	10:00-10:50A	CLB 316
Math	171	009	M	11:00-11:50A	CC 319

Note. From Johnson County Community College Credit Course Schedule, 2010c.

In addition to the extra hour shown on the college's credit class website, each experimental section listing included a note giving students additional information about why the extra hour of instruction was necessary. Figure 2 below shows an example of that note.

Note: Math 171-009, the section listed above, uses supplemental projects to enhance what is learned in the traditional classroom. Students who choose this section will learn the topics through additional activities that have been designed by the instructor for the course. Students are required to attend the extra sessions and take part in the additional activities. These course enhancements are part of the Achieving the Dream Initiative at JCCC.

Figure 2. Note of additional information for experimental sections. From Johnson County Community College, 2010c.

The supplemental sessions employed a modified version of the University of Missouri–Kansas City (UMKC) Supplemental Instruction (SI) model (Arendale, 2000). One peer tutor facilitated each experimental section; the peer tutor attended each class session held by the instructor, regardless of the number of class meetings. The peer tutor led the weekly supplemental project sessions, guiding the students through the materials prepared by the instructors. The instructor did not attend the weekly supplemental sessions. Unlike the UMKC SI model, which does not require student attendance at the SI sessions, the students in this study were required to attend supplemental sessions and the work completed in those sessions counted toward the students' final grades. The peer tutors met weekly with the instructor, providing feedback about the challenges or successes of the projects. JCCC offers full-semester classes in a 16-week format; the supplemental sessions lasted 12 weeks, beginning the second week of class and ending approximately three weeks before the end of the term. Students did not pay for the supplemental sessions.

In the supplemental sessions, the tutor organized students into small discussion groups; each group had approximately four students. In the spring of 2010, the researcher, working with the two instructors who would be participating in the fall, designed materials for the supplemental sessions. In May and June 2010, the two instructors who participated in the fall study worked collaboratively with the researcher to design materials for their supplemental project sessions. After the fall 2010 semester, the researcher interviewed the tutors in order to gather feedback about the effectiveness of the materials used in the supplemental sessions. The instructors participating in the spring 2011 study worked with the researcher in January 2011 to revise the project-session materials, making use of feedback gathered from tutors and students who had taken part in fall 2010.

The supplemental sessions included activities based on four College Algebra concepts: 1) the meaning of a function; 2) the characteristics of polynomials; 3) examples of exponential growth or decay; 4) sequences and series or systems of equations. Beyond College Algebra concepts, the sessions addressed twenty-first century learning outcomes (Wagner, 2008), including critical thinking and problem-solving, effective oral and written communication, and collaboration. Each of the four activities spanned three weeks of work. Part one, an introduction to the topic, allowed the students to work together to discover characteristics of the topic. In week two of each activity, students worked together to solve the problem woven throughout the topic. Students presented their findings to other session attendees and to the tutor during week three. The students repeated this pattern for each of the four activities.

Quantitative instruments. Four quantitative variables were of particular importance in this research. Variables studied included: 1) persistence in the class, determined by the last date of attendance for each student; 2) successful completion of the course, defined as earning at least a C in the course; 3) evidence of understanding of key course concepts, ascertained by an analysis of final exam data; and 4) attitude toward mathematics, utilizing a pre- and post-attitudinal survey.

***Persistence*.** The official grade roster submitted to the dean's office by each of the instructor indicated the last day of attendance for every student in the class. The names of students who dropped the course were listed on the grade roster and the date the drop took place was given. For the spring semester, the last day of the semester was May 20, which corresponds to day 140 on a table of days (Appendix I). Students who persisted through the entire course earned a score of 140; all other students earned numerical scores corresponding to the date of drop or the last day of attendance using a table of days. A student earned a persistence score of 140 if that student took the course final exam, even if the student did not pass the exam or the course.

***Successful completion*.** A student successfully completed the course if that student earned an A, B, or C as a final grade in the class. A student at JCCC must earn at least a "C" in order to enroll in a subsequent math course, or in most cases, to transfer the grade to another college or university (Wilson, 2008, pp. 19-20). The official grade roster submitted by instructors reported the final grade earned by each student. Grades of P (for pass) were not an issue for this study. A student taking a course Pass/Fail at JCCC files a form with the Records Office. Instructors were not aware of any student taking the class on a Pass/Fail basis and submitted letter grades for all students on the official class roster.

The ratio of the number of students who successfully completed the course, calculated by dividing the number of completers by the number of students enrolled on the twentieth day of the course, formed the quantitative measure of success for the study. The State of Kansas defines attendance as the number of students officially enrolled on the twentieth day of class.

Evidence of understanding of key course concepts**.** The JCCC mathematics division measured successful understanding of the course concepts through use of a Core Question Analysis (CQA) on the final exams. The division implemented the requirement of administering common final exams in 1990 (Wilson, 2008, p. 12). Math instructors have continued that practice (Johnson County Community College, 2010d). The course content coordinators (so called c-cubed instructors) wrote Core Questions, which are final exam questions that correspond directly to course outcomes. For example, one of the outcomes of College Algebra is to “Apply exponential and logarithmic equations to problems, e.g., growth and decay” (Johnson County Community College, 2011d, section 2d). The c-cubed instructors for College Algebra wrote Core Question 18 on the departmental final exam to test that outcome. An outline of the Core Questions for College Algebra appears in Appendix J.

While some veteran instructors receive permission from the dean to write their own final exams, all final exams must include the same Core Questions (Wilson, 2008, p. 19). After the spring 2011 semester, the mathematics division analyzed final exams of students in the experimental group (supplemental projects) and the control group (students in that same instructor's traditional class). For each student's final exam, the number of the ten Core Questions answered correctly (C) and the number of Core Questions on which the student made an error (E) were recorded. The percentage of students in the experimental who answered the Core Questions correctly were compared to those in the control class.

***Attitude*.** Students' attitudes toward mathematics were measured at the beginning and the end of the semester using a survey developed by Rachel Manspeaker at Kansas State University (Appendix D). With permission from Manspeaker, question one was modified to fit the parameters of the supplemental projects being studied (see Appendix K). While the KSU survey asked students whether they believed they could learn mathematics using spreadsheets, question one on the JCCC survey asked students if they believed they could learn mathematics through group projects.

Qualitative instruments. Creswell (2009) defined four types of qualitative data: observations, interviews, documents, and audio-visual materials. Observations and audio-visual materials were not used because the supplemental sessions were neither attended nor recorded by the researcher or participating instructors. Face-to-face interviews were conducted and documents in the form of online postings were analyzed. This section describes the details of each qualitative component of the study.

Online postings. Two instructors taking part in the study in spring 2011 individually created a series of questions; the intent of the questions was to provide feedback to the instructor about the supplemental project sessions (Instructor D, personal communication, August 16, 2011). The instructors posted questions to the Learning

Management System (LMS) for their respective classes with the requirement that students respond to the prompt or to another student's post. Nineteen students in one class responded at least twice; fourteen students in the other class responded multiple times. The instructors gave the researcher permission to analyze student comments contained within the LMS. The researcher analyzed all postings during summer 2011, coding data for themes that emerged (Creswell, 2009, p. 186).

Interviews. Creswell (2009) explained that face-to-face interviews are most effective when the researcher cannot directly observe participants; here, the researcher chose to incorporate a series of one-on-one, face-to-face interviews. The researcher interviewed three students, the two tutors who had facilitated the supplemental sessions, and four of the five instructors who participated in the study. Because the fifth instructor opted not to have a tutor facilitate the sessions, the researcher chose not to interview that instructor. Each student, tutor, and instructor interview lasted approximately one hour. The researcher conducted all interviews during the summer of 2011. Two of the students interviewed successfully completed College Algebra; one did not successfully complete the class. One of the instructors who participated in the study taught an experimental class in both the fall 2010 semester and the spring 2011 semesters. Both tutors participated during both the fall 2010 semester and the spring 2011 semester.

Data Collection

This study was approved by the IRB at Baker University (see Appendices A and B). Students signed an informed consent document before any interviews took place (see Appendix C). Although it was important for the researcher to be able to track individual students, participating students, tutors, and instructors were anonymous. Each student was assigned a numerical code, which was used throughout the study. Quantitative data—including last date attended, final course grade, performance on the departmental final exam (as defined by the CQA), and pre- and post- data from the attitude survey—were collected from participating College Algebra classes taught in the fall 2010 semester and the spring 2011 semester. Qualitative data—including interviews and online postings—were collected during the spring 2011 and summer 2011 semesters. The student interviews began with open-ended questions, asking students to compare their previous experiences in math classes with the class they had just taken. The second, more structured phase of student interviews, focused on questions and comments arising from the open-ended phase. The interview data were transcribed, coded, and triangulated.

Quantitative data. At the end of the fall 2010 and spring 2011 semesters, the researcher collected data on persistence for students in all experimental classes and control classes. Utilizing final grade rosters stored in the dean's office, the researcher determined the last date of attendance for each student and assigned a numerical score to that date. Students who remained in the course until the end of the semester (regardless of whether they passed the class or not) earned the highest score possible. Students who dropped the class or ceased attending the class received a score based on the number of days attended. The researcher used the last date of attendance to calculate the average time students persisted in the class.

Final fall 2010 and spring 2011 course grades from the official grade rosters submitted to the dean's office were used to calculate successful completion rates for students in all experimental classes and control classes. The successful completion rate was calculated by dividing the number of students who earned at least a C in the course by the number of students enrolled on the 20th day of the class.

All students enrolled in College Algebra at JCCC are required to take a departmental final exam. The departmental final exam contains ten core questions; each core question written to measure the student's understanding of one of the course outcomes as described on the course outline. Immediately after the spring 2011 semester, the researcher performed a Core Question Analysis (CQA) on all final exams taken by students participating in the study. The CQA consisted of examining the number of the ten Core Questions the student answered correctly (C) along with the number of core questions in which the students made an error (E). Using a tally sheet for each student, the total number of Cs and Es were entered on an Excel spreadsheet. Final exams from the fall semester had been shredded and were not available for analysis.

Each instructor taking part in the study administered an attitudinal survey twice during the semester: once during the first week of class and again near the end of the course. The student's unique code tracked that student's attitude from the beginning of the course until the end of the course. Using an Excel spreadsheet, the researcher entered a "1" for any statement for which the student indicated he or she strongly disagreed; a "2" for any statement for which the student somewhat disagreed; a "3" for any statement for which the student was ambivalent; a "4" for any statement for which the student somewhat agreed; and a "5" for any statement for which the student strongly agreed.

Qualitative data. Creswell (2009) described a protocol for qualitative data collection and recording procedures (p. 181). Using a digital device, the researcher recorded all student, tutor, and instructor interviews and transcribed those interviews immediately afterword. The researcher also recorded information during the interviews by taking notes. For the online postings, the researcher read all written student comments immediately after the spring 2011 semester. The process of coding online postings and interviews began by listing words and phrases that appeared multiple times in student responses, and then grouping words and phrases around themes that arose within student responses.

Student interviews consisted of three phases. In Phase 1, the researcher began by asking each student to describe his or her experience in math classes prior to this class. Next, the researcher asked the student to compare those earlier math classes with this most recent class. Finally, the researcher asked students to describe elements of the sessions that helped or hindered their learning, and whether their career plans changed because of the supplemental sessions. The researcher recorded and transcribed the answers to the open-ended questions (see Appendix C). In Phase 2, the three students responded to questions developed to tie earlier statements about learning mathematics to the specific activities that occurred in the sessions. For example, all three students mentioned the word “relationships” during Phase 1. The researcher asked each student to describe what he or she meant by relationships. The researcher recorded and transcribed the students’ answers to the questions in Phase 2. In Phase 3, the researcher presented each student with his or her written responses to each question from Phases 1 and 2, allowing each student an opportunity to make any changes to the transcript. During all phases of data collection and analysis, the researcher protected the identity of the students, ensuring that neither the student nor the student’s teacher could be identified. Students had opportunities to remove any details in their answers to any of the interview questions in order to maintain their anonymity. Final versions of transcripts from Phases 1 and 2, approved by the three participating students, appear in Appendix F.

The researcher conducted tutor and instructor interviews during the summer of 2011. The questions for tutors and instructors were nearly identical (see Appendix C). In addition to instructor interviews, two instructors who took part in the study in spring 2011 semester posted online weekly questions for students in their experimental classes. Instructors teaching those experimental classes expected students to respond (online) to those prompts within the week. Students responded by posting an original thought to the Learning Management System (LMS) or by responding to another student's comment. In summer 2011, the two instructors gave the researcher permission to access the student comments posted on the LMS. The researcher identified themes that arose within those discussions, which were directly related to research question five (To what extent do group activities in mathematics contribute to success for students in a community college).

Validity and Reliability

Several quantitative instruments measured student learning, the number of days students persisted in the class, the final grade the student earned in the class, performance on the final exam, as defined by a Core Question Analysis (CQA), and student attitudes toward mathematics. The course outcomes align with the ten Core Questions (see Appendix J). In order to determine additional criterion validity of the CQA, the Course Content Coordinators (C-Cubed instructors) examined the relationship between the College Algebra course outline and the ten Core Questions (personal communication, July 2011). That criterion validity was further examined using a regression analysis, using CQA as a predictor of final grade, the results of which are presented in table 4 below. The results of that regression analysis confirmed that CQA is highly predictive of whether or not the student successfully completed the course ($p < 0.05$), which further validates the use of CQA to measure conceptual understanding.

Table 4

Regression CQA as a predictor of Final Grade

Instructor	Type of Class	*R*	*p*
C	Control	0.87	0.000
	Experimental	0.86	0.000
D	Control	0.73	0.001
	Experimental	0.56	0.051
E	Control	0.86	0.000
	Experimental	0.75	0.004

As noted in table 4, with the exception of the experimental section taught by Instructor D, CQA is predictive of whether or not the student successfully completed the class, as defined by the course grade. In the case of Instructor D's experimental class, there is a strong positive correlation between CQA and final grade ($p = 0.051$).

Rachel Manspeaker (2010) at Kansas State University developed the attitudinal survey administered to students participating in the study. At the time the survey was used for this study, the mathematics department at Kansas State University had not yet validated the survey (see appendix K). The KSU mathematics department has subsequently posted the survey to its website; researchers at the college use the survey to pre-determine likely success in College Algebra, providing content validity of the attitudinal items.

Data Analysis and Hypothesis Testing

This study addressed three research questions. The first question contains three research hypotheses; the second research question contains one hypothesis; qualitative data was analyzed to address the third research question. A restatement of each research question along with a description of the hypothesis testing procedure used in the study is presented below.

Research question 1. To what extent do peer-led supplemental project-based instruction sessions increase the average number of days students persist, the percentage of students who successfully complete, and the level of understanding of mathematical concepts?

Research hypothesis 1. *Peer-led supplemental project-based supplemental sessions increase the average number of days students persist in a College Algebra class at a community college.* Student persistence in the class was measured using a numerical score for the number of days each student remained in the course. Students who persisted until the end of the semester earned a score of 140 days (the maximum); students who dropped the class prior to the last day earned a score corresponding to the number on a table of days (Appendix H). A *t* test for independent samples compared the mean number of days persisted for students in aggregate control classes to students in aggregate experimental classes. An analysis of disaggregated persistence data by instructor compared the mean number of days attended for each of the five instructors' experimental class to that same instructor's control class. The results of a right-tailed *t* test using unequal sample sizes (Weiss, 2010) determined if students in each instructor's experimental class persisted longer than students in that same instructor's control class.

Research hypothesis 2. *Peer-led supplemental project-based instruction sessions increase the percentage of students who successfully complete a College Algebra class at a community college.* Successful completion of the course, as defined by the JCCC Math division (Wilson, 2008) and the Achieving the Dream (AtD) initiative (Achieving the Dream, 2010), means the student earned at least a C in the course. A right-tailed z test for two population proportions determined if students in the aggregated experimental classes outperformed students in the control classes. Using data disaggregated by instructor, the results of a right-tailed z test for two population proportions suggested whether the percentage of students successfully completing the course was higher for students in the experimental class than students in that same instructor's control class.

Research hypothesis 3. *Peer-led supplemental project-based instruction sessions increase the level of understanding of mathematical concepts for students in a College Algebra class at a community college.* A hypothesis test for two population proportions using a right-tailed z test determined whether the percentage of Cs (correct Core Questions) in the aggregated experimental classes was higher than the percentage of Cs in the aggregated control classes. Disaggregated data by instructor tested if the proportion of Cs for students in the project-based supplemental instruction class was higher than the proportion of Cs of students who were in that same instructor's control class.

Research question 2. To what extent do peer-led supplemental project-based instruction sessions improve attitudes toward mathematics?

Research hypothesis 4. *Peer-led supplemental project-based instruction sessions change attitudes toward mathematics for students in a College Algebra class at a community college.* The classroom instructors taking part in this study administered both a pre- and post-attitudinal survey. A two-tailed paired *t* test for mean differences in pre- and post-attitudes for students in the aggregated control and experimental classes, conducted shortly after the end of the fall 2010 and spring 2011 semesters, determined if students in experimental and control classes were equally likely to change their attitudes toward mathematics. Using disaggregated attitudinal data by instructor, the results of a two-tailed paired *t* test tested suggested whether a change in attitude on any of the ten items produced significant mean differences for students in the experimental class compared to students in that same instructor's control class.

Research question 3. To what extent do peer-led supplemental project-based instruction sessions coupled with classroom instructional strategies contribute to overall success for students in a College Algebra class at a community college?

In order to determine a possible connection between activities in the project-based supplemental sessions and student success in mathematics, the researcher studied qualitative data including online posts and transcriptions of interviews with selected students, tutors, and participating instructors. The perspectives among the three groups were compared for similarities and differences. Creswell (2009) explains the analysis of qualitative data as "an ongoing process involving continual reflection about the data" (p. 184). Denzin & Lincoln (2008) describe qualitative researchers as "tend[ing] to perceive events as Tolstoy did in *War and Peace*—multiply sequenced, multiply contextual, and coincidental more than causal" (p. 127). The purpose of adjoining a qualitative element to this mixed-methods study was not to find simplistic answers to the difficult questions posed in chapter one. Rather, the purpose was to provide a context for the data analyzed in the quantitative portion of the study.

Limitations of the Study

Because data gathering occurred during a serious downturn in both the local and national economies, it is possible that any significant increase in student persistence could be explained by lack of job opportunities for students rather than by the initiatives themselves. In addition, students opting to enroll in one of the experimental sections may not have had similar characteristics as students in one of the control sections. One participating instructor explained that more students who were repeating the class enrolled in the experimental section, hoping the extra hour would help them succeed (Instructor E).

Summary

This study determined the effect of project-based supplemental instructional sessions for students enrolled in a College Algebra course at a community college. The quantitative portion of the study provided a numerical basis for ascertaining whether required project-based supplemental instructional sessions led to any significant increases in persistence, student success, or student understanding of concepts, or whether students experienced a significant change in attitude toward mathematics. Qualitative data provided additional information about elements of peer-led supplemental project-based instruction sessions that could lead to success in mathematics. The quantitative relationships between elements of peer-led supplemental project-based instruction sessions and persistence, student success, performance on the final exam, and change in attitude examined, in each case, the relationships between 1) aggregate experimental classes and the aggregate control classes and 2) each instructor's experimental class and that same instructor's control class. Qualitative components including online postings and student, tutor, and instructor interviews further illuminated the quantitative data, adding specific language and voices, expanding on the findings of one method with another method (Creswell, 2009, pp. 9-14). Chapter 4 presents a summary of the descriptive statistics along with the results of the four hypothesis tests. The chapter concludes with an analysis of the qualitative data.

Chapter Four

Results

This chapter presents data on the effect of peer-led supplemental project-based instruction sessions for students (n = 243) enrolled in a College Algebra course at a community college. The results of quantitative data analysis on persistence, success, understanding of key course concepts, and attitude toward mathematics, along with the results of qualitative data analysis on student, tutor, and instructor perceptions of the effectiveness of these supplemental sessions are presented. Figure 3 provides a visual representation of the independent and dependent variables addressed by this study.

Independent Variables

Supplemental mathematical projects facilitated by peer-tutors coupled with a traditional class and traditional class only

Dependent Variables

Persistence (Quantitative)

Successful course completion (Quantitative)

Performance on final exam (Quantitative)

Attitude toward mathematics (Quantitative)

Student, tutor, and instructor perceptions of effectiveness of supplemental sessions (Qualitative)

Figure 3. Independent and Dependent Variables

Several statistical analyses, determining the strength of the relationships of the independent and dependent quantitative variables, were performed. To analyze the four hypotheses, aggregate experimental classes were compared to aggregate control sections. Next, the researcher compared each instructor's experimental section with his or her control section to test for significant differences. A value of $p < 0.05$ was used to determine any significant differences that occurred. For hypotheses one and four, the researcher employed *t* tests for independent samples; for hypotheses two and three, *z* tests for population proportions were used to analyze data. Figure 4 provides a summary of those quantitative tests used. (See chapter three for a more detailed description.)

Dependent Variable Studied	**Statistical Test**
Persistence	*t* test for two population means
Successful course completion	*z* test for two population proportions
Performance on final exam	*z* test for two population proportions
Change in attitude toward math	*t* test for two population means

Figure 4. Statistical Tests Used in the Study.

Hypothesis Testing

Research question one. To what extent do peer-led supplemental project-based instruction sessions increase the average number of days students persist, the percentage of students who successfully complete, and the level of understanding of mathematical concepts? Table 5 provides descriptive statistics for the mean number of days students persisted in the experimental and control sections.

Table 5

Descriptive Statistics for Number of Days Students Persisted (Aggregate Data)

Class Type	*N*	*Min*	*Max*	*M*	*SD*
Experimental	116	48	140	125.7	24.7
Control	127	26	140	127.4	26.2

Next, the researcher disaggregated student persistence data. Table 6, shown below, provides descriptive statistics on the mean number of days students persisted when categorized by instructor.

Table 6

Descriptive Statistics for Number of Days Students Persisted by Instructor

Instructor	Class Type	*N*	*Min*	*Max*	*M*	*SD*
A	Experimental	25	70	140	131.5	18.5
	Control	25	88	140	134.8	13.9
B	Experimental	24	48	140	118.3	32.5
	Control	28	50	140	127.0	25.2
C	Experimental	26	68	140	127.3	22.8
	Control	22	26	140	122.1	36.6
D	Experimental	22	73	140	124.9	21.4
	Control	25	52	140	124.1	29.3
E	Experimental	19	52	140	125.9	26.7
	Control	27	67	140	128.2	22.8

***Research hypothesis 1**. Peer-led supplemental project-based supplemental sessions increase the average number of days students persist in a College Algebra class at a community college.* Using a *t* test for independent samples, the mean number of days persisted for the aggregated experimental classes was compared to the mean number of days persisted for the aggregated control classes to see if students in the experimental classes persisted longer. The results of that hypothesis test are presented in table 7 below.

Table 7

Results of Aggregated Two-Sample t Test for Persistence (Aggregate Data)

No. of Days Persisted	*N*	*t*	*df*	*p*	Mean Diff.
All Control vs. Exp.	243	-0.52	240	0.699	-1.72

Next, the data were disaggregated by instructor, and a non-pooled *t* test for two independent samples (Weiss, 2005) was performed to determine whether students in the experimental class persisted longer than students in that same instructor's control class. In this case, the non-pooled *t* test was appropriate because of the relatively large differences in standard deviation between the control classes and experimental classes when disaggregated by instructor (see table 6). The results of the non-pooled *t* tests are presented in table 8.

Table 8

Results of Two-Sample t Test for Last Date Attended Disaggregated by Instructor

Last Date Attended	*N*	*t*	*df*	*p*	Mean Diff.
Instructor A	50	-0.7	44	0.756	-3.24
Instructor B	52	-1.06	43	0.853	-8.67
Instructor C	48	0.57	34	0.285	5.17
Instructor D	47	0.11	43	0.458	0.78
Instructor E	46	-0.31	34	0.620	-2.33

The results of the first *t* test indicated that students in the aggregated control classes persisted slightly longer on average than students in the experimental classes; however, the difference was not statistically significant ($p = 1 – 0.699 = 0.301$). The results of the disaggregated data analyses revealed students in an experimental class did not persist statistically significantly longer than students in that same instructor's control class, regardless of the instructor teaching the class ($p > 0.05$ for all five analyses).

Research hypothesis 2. *Peer-led supplemental project-based instruction sessions increase the percentage of students who successfully complete a College Algebra class at a community college.* Successful completion of the course, as defined by the JCCC Math division (Wilson, 2008) and the Achieving the Dream (AtD) initiative (Achieving the Dream, 2010), means the student earned at least a C in the course. Table 9 presents the number of successful students by instructor and section as well as the number of students who chose to drop the course.

Table 9

Frequencies of Student Drops and Successes by Instructor

Instructor	Class Type	*N*	# Dropped	# Successful
A	Experimental	25	5	15
	Control	25	4	16
B	Experimental	24	9	8
	Control	28	7	19
C	Experimental	26	7	13
	Control	22	5	12
D	Experimental	22	8	11
	Control	25	7	15
E	Experimental	19	5	11
	Control	27	7	13

Figure 5 (shown below) provides a histogram of the distribution of final grades for the aggregate experimental classes; a relatively large number of students did not succeed despite the required supplemental sessions.

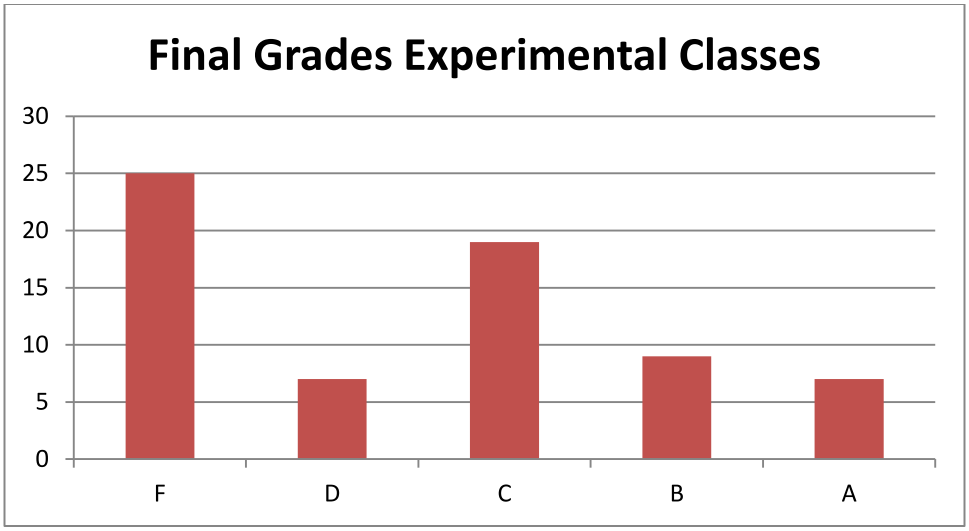

Figure 5. Histogram of Final Grades of Experimental Classes

Figure 6 provides a histogram of the distribution of final grades for the aggregate control classes. Although more students earned B grades than counterparts in experimental classes, the distribution of grades was similar to the distribution of grades in the experimental classes.

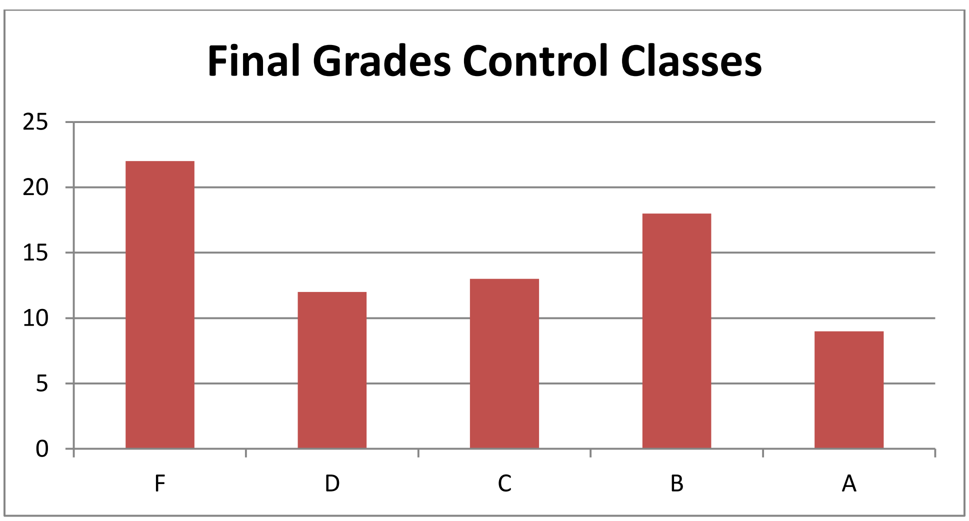

Figure 6. Histogram of Final Grades of Control Classes

To test research hypothesis 2, a *z* test for two population proportions was performed to determine if the proportion of successful completers in the aggregated experimental classes (58 out of 116 = 50%) exceeded the proportion of successful completers in the aggregated control classes (75 out of 127 = 59%). Table 10 provides the results of that hypothesis test.

Table 10

Results of Aggregated z Test for Successful Completion

Successful Completion	*N*	*z*	*p*	Difference
All Control vs. Exp.	243	-1.42	0.922	-0.09

Next, the data were disaggregated by instructor, and a *z* test for two population proportions was performed to determine if students in one of the experimental classes were more successful than students in that same instructor's control class. The results of that hypothesis test are presented in table 11.

Table 11

Results of z Test for Successful Completion by Instructor

Successful Completion	*N*	*z*	*p*	Difference
Instructor A	50	-0.29	0.615	-0.04
Instructor B	52	-2.64	0.996	-0.35
Instructor C	48	-0.31	0.623	-0.05
Instructor D	47	-0.69	0.755	-0.10
Instructor E	46	0.66	0.256	0.10

The results of the *z* tests indicated that students in the control classes tended to be more successful than students in the experimental classes were. In fact, in the class taught by instructor B, students in the control class were significantly more successful; no other instructor's class showed a significant increase in success when comparing the experimental class against the control class.

Research hypothesis 3. *Peer-led supplemental project-based instruction sessions increase the level of understanding of mathematical concepts for students in a College Algebra class.* The results of the descriptive statistics of the Core Question Analysis (CQA) for spring 2011 cohorts are presented below. As noted in chapter three, final exam data for fall 2010 were not available for analysis. Table 12 provides information by class on the percentage of the ten questions students answered correctly.

Table 12

Descriptive Statistics of Core Question Analysis (CQA) for Spring 2011

Instructor	Class Type	N	%Correct
C	Experimental	19	50.0
	Control	17	52.3
D	Experimental	14	38.6
	Control	18	47.7
E	Experimental	14	45.7
	Control	20	46.5

Using a z test for two population proportions, analysis of CQA data was performed to determine whether students in the experimental classes answered a larger percentage of core questions correctly than students in the control classes did. The results of that hypothesis test are presented in Table 13 below.

Table 13

Results of Aggregated z-test for Core Question Analysis

Correct Core Questions	*N*	*z*	*p*	Mean Diff.
All Control vs. Exp.	102	-1.09	0.862	-0.03

Next, data were disaggregated by instructor and a *z* test for two population proportions was performed to determine if students in an experimental class answered a larger percentage of Core Questions correctly than students in that same instructor's control class did. Table 14 provides the results of that inferential analysis.

Table 14

Results of z Test for Core Question Analysis by Instructor for Spring 2011

CQA	*N*	*z*	*p*	Mean Diff.
Instructor C	36	-0.45	0.672	-0.02
Instructor D	32	-1.66	0.961	-0.92
Instructor E	34	-0.14	0.557	-0.10

The results of these *z* tests indicated that students in the aggregated control classes showed a higher level of understanding of course concepts than students in the aggregated experimental classes. When the Core Questions were disaggregated by instructor, all three instructors had higher levels of conceptual understanding in their control classes than in their experimental classes. In fact, in Instructor D's class, students in the control class scored significantly higher when compared to students in Instructor D's experimental class.

Research question 2. To what extent do peer-led supplemental project-based instruction sessions change the attitudes toward mathematics of students in a College Algebra class at a community college? Using an attitudinal survey (see Appendix D), students rated their perceptions of learning mathematics. Table 15 provides mean ratings for each of the ten attitudinal prompts for control classes, from the beginning of the semester (pre) until the end of the semester (post).

Table 15

Mean Ratings on Attitudinal Survey Prompts by Instructor for Control Classes

Instructor		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	Pre	3.79	3.39	2.82	4.11	4.43	3.11	3.93	3.79	3.75	3.86
	Post	4.00	3.32	2.77	4.45	4.64	2.91	3.77	3.82	3.91	3.77
B	Pre	3.31	3.38	2.76	4.21	4.66	2.90	3.21	3.38	3.34	3.48
	Post	3.52	2.81	2.81	4.29	4.43	2.76	3.62	3.71	3.67	3.67
C	Pre	3.77	4.41	2.68	4.14	4.55	3.27	3.55	3.27	3.36	3.41
	Post	3.47	3.47	2.47	4.53	4.67	3.67	4.13	3.21	3.73	3.67
D	Pre	3.70	4.20	3.00	4.00	4.80	3.00	3.57	3.17	3.53	3.50
	Post	3.53	3.18	3.41	4.71	4.53	3.65	3.65	3.59	3.59	3.24
E	Pre	3.96	4.54	2.81	4.04	4.58	3.19	3.85	3.92	3.73	3.92
	Post	4.00	2.74	2.84	4.16	4.74	2.68	3.89	4.42	4.16	4.16

Table 16 provides mean ratings for each of the ten attitudinal prompts for the experimental classes.

Table 16

Mean Ratings on Attitudinal Survey Prompts by Instructor for Experimental Classes

Instructor		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	Pre	4.03	3.59	2.79	4.10	4.52	3.52	3.55	3.69	3.55	3.93
	Post	3.85	3.20	2.80	4.45	4.50	3.20	3.50	4.21	4.15	4.05
B	Pre	4.00	3.65	2.91	4.35	4.43	3.13	3.96	3.65	3.52	3.61
	Post	3.53	2.80	3.27	4.13	4.53	3.07	3.00	3.20	3.07	3.47
C	Pre	3.57	4.07	3.11	4.57	4.54	3.32	3.32	3.21	3.04	3.25
	Post	3.06	3.18	3.22	4.78	4.56	3.89	3.17	2.50	2.78	3.11
D	Pre	4.12	4.12	3.04	4.36	4.68	3.56	3.76	3.12	3.12	3.40
	Post	4.00	3.50	4.00	4.36	4.64	4.07	3.71	3.64	3.86	3.86
E	Pre	4.05	4.16	2.95	4.42	4.53	3.68	3.42	2.89	2.95	3.05
	Post	4.07	3.29	2.85	4.29	4.93	3.43	3.50	3.64	3.64	3.62

Research hypothesis 4. *Project-based supplemental sessions in a College Algebra course change attitudes toward mathematics.* To determine if there was a significant difference in the mean for any of the attitudinal prompts in the control classes, paired *t* tests were utilized. The results of those tests are shown in Table 17.

Table 17

Results of Paired t-Tests of Mean Attitudinal Difference for Aggregate Control Classes

Attitude: Ctrl. Pre to Post	*N*	*t*	*p*	95% CI LL*	95% CI UL*
Question 1	93	0.64	0.525	-0.136	0.265
Question 2	93	-7.13	0.000	-1.210	-0.683
Question 3	93	0.49	0.624	-0.196	0.325
Question 4	93	2.78	0.007	0.083	0.498
Question 5	93	-0.48	0.630	-0.220	0.134
Question 6	93	0.81	0.420	-0.156	0.371
Question 7	93	0.72	0.475	-0.152	0.324
Question 8	92	0.93	0.353	-0.111	0.306
Question 9	93	1.12	0.267	-0.101	0.359
Question 10	93	0.09	0.925	-0.215	0.237

*A 95% confidence interval with LL= lower limit and UL=upper limit

The results for a paired *t* test to determine if any of the attitudinal prompts differed significantly from pre- to post- for the aggregate experimental classes are presented in table 18 below.

Table 18

Results of t-Test of Mean Attitudinal Difference for Experimental Classes

Attitude: Exp. Pre to Post	*N*	*t*	*p*	95% CI LL*	95% CI UL*
Question 1	80	-2.57	0.012	-0.554	-0.071
Question 2	80	-4.33	0.000	-0.967	-0.358
Question 3	80	1.78	0.079	-0.028	0.503
Question 4	81	0.59	0.559	-0.118	0.217
Question 5	81	0.91	0.365	-0.103	0.275
Question 6	81	0.55	0.584	-0.194	0.342
Question 7	81	-2.37	0.020	-0.545	-0.048
Question 8	80	0.31	0.755	-0.201	0.276
Question 9	81	0.27	0.709	-0.239	0.313
Question 10	79	1.66	0.100	-0.037	0.417

*A 95% confidence interval with LL= lower limit and UL=upper limit

The results of the *t* tests indicated statistically significant changes in attitude for the control classes on questions 2 (Mathematics is a worthwhile subject to learn) and 4 (It is very important to me that I attend a small class where the instructor can keep track of my progress). Significant differences in attitude were present in the experimental classes on questions 1 (I believe I can learn mathematics through group projects), 2 (Mathematics is a worthwhile subject to learn), and 7 (I anticipate using math in my future career).

Based on the results, further analysis was warranted for questions 1, 2, and 7; question 4 only showed a significant change for control classes and was therefore not examined further. In order to isolate the effect of the supplemental sessions on the change in attitude (and not teacher or other effect), each instructor's experimental class was compared to that same instructor's control class for statistically significant change in attitude on questions 1, 2 and 7. Those data are presented in table 19.

Table 19

Mean Change in Attitude for Questions 1, 2, and 7 by Instructor

Instructor	Class Type	Change Q1	Change Q2	Change Q7
A	Control	0.14	-0.32	-0.18
	Experimental	-0.25	-0.35	-0.25
B	Control	0.52	-0.52	0.33
	Experimental	-0.50	-0.21	-0.71
C	Control	-0.36	-0.86	0.64
	Experimental	-0.44	-0.83	-0.17
D	Control	-0.35	-1.41	-0.24
	Experimental	-0.29	-0.64	-0.21
E	Control	0.22	-1.78	0.06
	Experimental	0.21	-0.71	0.29

Using the disaggregated data, a non-pooled *t* test for two independent samples was performed to compare changes in sample means of attitudinal prompts for experimental and control groups by instructor. However, it should be noted that disaggregating the data by instructor yielded relatively small sample sizes. Table 20 gives the results of those hypothesis tests.

Table 20

Results of Two-Sample t Test for Change in Attitude on Questions 1, 2, and 7

Change in Attitude	*N (Ctrl, Exp)*	*t*	*df*	*p*	Mean Difference
Instructor A					
Q1	22, 20	-1.35	39	0.184	-0.39
Q2	22, 20	-0.09	33	0.931	-0.03
Q7	22, 20	-0.18	39	0.856	-0.07
Instructor B					
Q1	21, 14	-2.69	28	0.012*	-1.02
Q2	21, 14	0.88	26	0.389	0.31
Q7	21, 14	-2.65	32	0.012*	-1.05
Instructor C					
Q1	14, 18	-0.22	26	0.828	-0.09
Q2	14, 18	0.06	29	0.955	0.02
Q7	14, 18	-2.59	29	0.015*	-0.81
Instructor D					
Q1	17, 14	0.19	27	0.853	0.07
Q2	17, 14	1.40	28	0.172	0.77
Q7	17, 14	0.06	28	0.955	0.02
Instructor E					
Q1	18, 14	-0.02	18	0.985	-0.01
Q2	18, 14	1.98	26	0.058	1.06
Q7	18, 14	0.50	17	0.622	0.23

Note: * Indicates significant change at $p < 0.05$

With the exception of Question 7 for Instructor C, there was no significant difference in the change in attitude in ratings of prompts between the control and experimental classes during the spring semester using the disaggregated data. During the fall semester, significant differences were present in Questions 1 and 7 for Instructor B; students in

Instructor B's control class rated "I believe I can learn math concepts through group projects" and "I anticipate using math in my future career" higher than cohorts in Instructor B's experimental class did.

Research Question 3. To what extent do peer-led supplemental project-based supplemental sessions in mathematics contribute to success for students in a community college? In order to determine a possible connection between the project-based supplemental sessions and student success in mathematics, the researcher conducted a series of interviews with selected students, with tutors, and with participating instructors. Two instructors involved in the study during the spring posted questions online; students in their experimental classes posted responses to those questions. Comments from interviews and postings were categorized for common themes. Seven common themes emerged from this analysis: 1) success; 2) understanding; 3) fairness and complaints; 4) communication and interaction; 5) relationships and collaboration; 6) extra help; and 7) involvement. Summarized qualitative data from interviews and online postings by participant type (student, tutor, faculty), thematic category, key terms, and sample quotes, is presented in table 21.

Table 21

Thematic Categories from Interviews and Posts

Participant type	Thematic Category	Key Terms	Quotes
Student, Instructor	Success	Pass, high grade, graduate, succeed, persist, work together, tutor, lack of fear of math	"Passing with a good grade…" "I know this will be difficult but rewarding"
Student, Tutor, Instructor	Understanding	Understand, grasp, comprehend, apply, recognize, accomplish, learning styles, teaching, coaching, going beyond skills	"actually understanding algebra" "these are the types of things I would do if I had time"
Student, Tutor	Fairness/Complaints	Extra hour, more work, additional sessions	"it was an extra hour we didn't get credit for" "have we done enough to leave?"
Tutor, Instructor	Communication and Interaction	Openness, lack of fear, insights, how they felt about the class	"They are more open with the tutor than they are with me"
Student, Tutor, Instructor	Relationships and collaboration	Community, groups, meeting new people, work with friends, talking, candid, cooperation, insight, sharing, synergy,	"the most beneficial part of the supplemental sessions was getting to interact with my classmates more"
Student, Tutor	Extra Help/Special bond with tutor	Private tutor, study groups, extra study sessions	"just having some extra time with the tutor each week really helped me"
Tutor, Instructor	Involvement	Attended sessions, got into projects, asked questions, talked to each other	"there was a competitive energy – students really got excited about the learning"

Within the three homogenous subgroups (students, tutors, faculty), interviewees showed consistency in their descriptions of the seven themes. However, those descriptions did not necessarily match those of participants in other subgroups. For example, while students described success as completing the course, instructors had a broader definition. In some specific areas (such as relationships and collaboration) comments among the three subgroups were nearly identical. In other thematic areas (such as fairness, understanding, and success), the comments were noticeably different. The next section describes the major comments written or spoken by members of the three subgroups along with specific quotes.

Success. Students, tutors, and instructors used the term "success" in interviews; however, that term may have connoted different meaning to those groups. Students defined success as passing the class, getting a high grade, graduating, or learning the fundamentals to help them succeed in future math classes. For example, one student commented that it was important that he "pass with a good grade and actually understand algebra because it will be beneficial to my future career." Other students defined success as simply getting through the course. Several students, in posts and interviews, described how many times they had taken College Algebra and dropped or failed the course. For these students, success meant simply getting through the class (Student CS; Student JW). One student summarized the sessions by stating, "I could not have passed it without the help of those group sessions that we did" (Student JW).

Instructors talked about the lack of success currently occurring in College Algebra. Instructor B stated, "I saw the problems present in the current College Algebra course." Instructors spoke about trying new things in order to get more students through the class, lower the drop rates, and help students make connections between the material in the class and real-world applications. Instructor D noted, “I think sometimes they don’t see those connections between what they are doing in math and how that extends outside of the classroom.” Overall, instructors’ definition of success was broader, including the hope that beyond completing the course, students would become better mathematical thinkers. In reflecting on the overall success of the sessions, Instructor B explained:

> I think having seen a number of the students do better, in particular, it was very noticeable when we got to the end of the course when we were dealing with sequences and series. The groups who had the sessions were much more willing to investigate patterns and try things whereas the control group was still interested in looking for formulas. And that was a terrific result.

Understanding. Some students talked or wrote about the importance of understanding in order to earn a high grade, do well in the next class, or achieve a career goal. Student JM explained, “What I am looking for in this class it to completely understand the material.” Other students noted the sense of accomplishment they felt after solving one of the difficult problems presented in the sessions. Student SO remarked, “I kind of liked it because once I did come to a conclusion, it always felt really good.” Many students described “understanding” as knowing which formula to use. Tutors tended to talk about the importance of understanding because of their love of math and wanting that passion to rub off, with the possibility of creating more math enthusiasts. Tutor H noted, “I have an infectious type of enthusiasm for math and I was hoping that would kind of rub off.” Tutor H also explained how these sessions reminded him of how he needed to be more aware of differences in student learning styles. Instructors tended to talk about the need to go beyond the teaching of skills. They described the need to have students reach a higher level of understanding of the material. Instructors also talked about not having the time to do these kinds of extra activities in their classes because of the amount of material they needed to cover. As Instructor D explained, “The College Algebra curriculum is so full that it is hard to get everything done that we want to get done, and so doing some of those connections and some of those fun things, we don’t really get to that very often.”

Students used the word “understand” to describe one particular session activity: the session on exponential growth. For that topic, students had to research interest rates banks were currently offering in order to solve the embedded problem. Several students reported they had a better understanding of the concept of exponential growth because of this activity. Student EW described the topic this way: “I believe the group session when we were asked to do research on the college fund was the most beneficial. I found it to be truly interesting.”

Fairness and complaints. Students complained to the tutor about having to spend an extra hour working on math but not getting credit for it. (The instructors involved in the study assigned points to the sessions and counted work toward the student’s final grade.) Students also expressed concerns about the fact that other College Algebra students did not have to attend extra sessions while they did. (Supplemental sessions for students in the experimental classes were mandatory.) Student SC commented that, “In the beginning, we all complained about it but in the end, only a few people complained about the sessions.” Student JW complained: “quite a few of us [were not happy] in the beginning when we heard we would have another hour after the class—to sit through more math. No one would want to do that unless you wanted to be a math teacher." Students who did not see an immediate positive impact on their grades in the class complained that the sessions were a waste of time. Student CS explained that she, "expected to get higher grades on my tests and when I didn't, I wondered why I bothered to go to the sessions." Tutors stated that they occasionally had to deal with negative comments from students; those ensuing discussions cut into their project time. Tutor H noted that, "there was a guy that was so negative he started rubbing off on other people. Other people finally told him to tone it down." One student explained it this way: "I am always a positive person so sometimes when other students would get real negative about something and it would just frustrate me" (Student SC). Tutors also stated that some of the projects seemed like busy-work to many of the students. One tutor explained that, "project 4 was a dud. The scale was too large" (Tutor I). Another tutor remembered that students sometimes complained that, "the projects did not pertain to anything we will be doing in the class" (Tutor H).

Communication. Several communication and interaction themes emerged within the comments of students, tutors, and instructors. Tutors and instructors, in describing the relationship between tutors and students, talked about the differences in the ways students communicated when the instructor was not present. Instructor B was particularly cogent in his explanation of those differences in communication:

> The biggest thing I learned from working with the tutor is that the tutor was very free of the negative connotations that come with being an instructor. The students were quite open with him in ways that they were not with me. I guess there is less

> fear of being seen negatively by the tutor. So, he had a lot more ability to relate to students, I think, than I did. I'm actually kind of envious.

The tutors shared some of the same sentiments, noting that students would often be very candid with them about their feelings toward the projects or the class. In addition, tutors and instructors noticed increased student interaction with an emphasis toward mathematical thoughts and ideas. One instructor observed more communication among students in the classroom, which he attributed to the fact that "they were together for an hour once a week talking to each other" (Instructor E). One tutor observed that more students arrived early to class to talk with him and each other about the projects, homework, or exams (Tutor H). Instructor A commented, "I did hear one student talking about a test question who said, 'We talked about this in our groups. I did the problem right because we did this in our group.'" Another instructor remembered a posting from one student, who noted, "I didn't realize how having someone to talk about it with, what a difference that would make" (Instructor D).

Relationships and collaboration. Students often spoke or wrote about the importance of their group. Student JW wrote, "The group work helped to strengthen my understanding in how to determine end behavior, and how to plot and determine zeros." For some, the importance of the group changed throughout the semester. One student began the semester with this posting:

> I don't know how I feel about the supplemental project part of the class. I've never been big with working in groups because I like to work at a fast pace and hate waiting for the rest of the group to catch up (Student EM, February 14, 2011).

That same student wrote this posting at the end of the semester:

> The most beneficial part of the supplemental sessions for me…hmm…I would have to say learning to work in groups, although in the past it has not been my favorite thing (Student EM, April 27, 2011).

Another student wrote that, “Working with friends really did help out a lot and made me more comfortable in class” (Student AZ). Still another student commented that, “It was almost like we went to summer camp together” (Student SC). In the early days of the spring sessions, Tutor I heard students say, “We are going to be in this three-person or four-person group for the next four weeks; we need to look out for each other.” Tutors not only mentioned the relationships they built with students, but also the joy of working closely with the instructor. One tutor explained, “I am interested in becoming a professor and I thought that being involved with it would give me a chance to work more closely with the professor” (Tutor I). Another tutor, reflecting on what he learned from the instructor’s lectures, mentioned, “There’s always a billion different ways to explain something and you are taught in a certain way and that tends to stick with you. But you hear it presented in a different way and you think, ‘hey, I never thought about it like that’” (Tutor H). Tutor I described how attending class and watching the relationships instructors built with students helped him know “where to draw the line on what is too much emotional investment.” Instructors described the positive aspect of working with the tutors and with each other as they developed the materials for the projects. Instructor A explained it this way:

> I learned something about improving how to ask questions. Because we worked on that—we hammered out not only questions but the wording of activities—I

> realized how important that is. When you are working by yourself, you don't tend to ask yourself, "Does this really come across the way I want?" I learned that. I think I learned it was okay to not feel that I am in competition with other instructors. I think that can happen when you get together with other colleagues and feel like you have to compete with each other. I did not feel that at all.

Instructor E, however, noted that the collaboration could have been better, stating, "It was a challenge for the instructors involved to have the time to get together." Another instructor talked about the collaboration between students, explaining that not all individuals in the groups would always work equally well together. He thought about, "how individual students were affected by working in groups—how some of them grew and how some of them reacted negatively" (Instructor B).

Extra help/special bond with tutor. On the first day of Instructor E's class, as he was telling the class about the required project sessions, he overheard a student tell another student, "The best part is that you get your own personal tutor." According to Instructor E, that student had heard about the supplemental session class from a friend who had taken the class in the fall. Students, in general, described a feeling that by taking this kind of class, they could always get extra help from their tutor. Student AZ stated, "Just having some extra time with the tutor each week went a long way in helping me with my math." One student, in describing the role the tutor played, explained, "It was nice to get a second person's input on what we learned in class and to answer questions" (Student EC). Student SC put it this way: "The tutor was just one of us. Whenever we talked about how old he was we told him you don't seem old; you seem like one of us." The tutors described a special connection with students in their sessions.

Tutor H told how he heard from many of his students letting him know how they performed on the final exam. Instructor B stated that students told him they had “chosen not to withdraw because they had their own special tutor.”

By far, the most poignant story came from Tutor I. He described the special bond formed with his class and one memorable evening.

> In the spring session, (I hope I can get through this—it’s kind of emotional), in addition to meeting as a group, they also started to get together before midterms and things like that. For a couple of those sessions I showed up to help them out. One of them was when they were all coming here the night before the midterm; there was the night to do the review, the midterm the next day, and the drop deadline was the day after that. That review session happened to be on my birthday. But my family, we have always been we can celebrate our birthdays on the weekends and I told the students I would come. The word got out that I was doing this on the evening of my birthday. And one student pulled me aside beforehand and said, “I was actually going to drop the class this afternoon but I knew that you were coming to the review session on your birthday. So here I am.” And she passed the class. And she was also in the first trimester of her first pregnancy.

Involvement. Tutors made several comments about the involvement of some of the students in the class and the lack of attendance by others. One tutor noted that it was particularly difficult when only one student would show from a particular group. He would then have to put that one student in another group, which tended to disrupt their work (Tutor I). Tutor I described the challenges of getting students to attend this way:

"One person deciding not to come to the group session that day affected others. It was a little different from missing a day of lecture for whatever reason. That had consequences beyond themselves." Instructors also lamented the difficulty they had getting students to attend the sessions, in spite of the fact that the sessions counted toward the students' final grades. Instructor D explained, "On any given day, if I had 15 students in the class, we were lucky to get 10 to attend the supplemental session." Instructor B described several students who hurt their grade because those students refused to participate in the sessions.

Summary

Quantitative analysis of data provided no evidence of significant improvement in persistence, successful course completion, or understanding of key course concepts for students in the experimental group. Further analysis suggested a lack of significant change in attitude toward mathematics among those same students. Results of the analysis of qualitative data, however, suggested a more robust relationship between the collaboration that occurred in the supplemental sessions, the strong relationships built with the tutor and other students, and persistence in the class. Further qualitative analysis of online postings and student interviews indicated an increase in students' ability to think critically and to communicate about mathematics. The next chapter, which includes a summary of the study, analysis of the results, and implications for future research, explains why these findings, while seemingly contradictory, are important to community college researchers.

Chapter Five

Interpretation and Recommendations

Passing College Algebra matters. This study provided evidence that many community college students will take advantage of opportunities that could increase their chances of success, including one that requires them to spend an additional hour each week working on mathematical projects. This chapter begins with an overview of the problem investigated, re-states the purpose and methodology, presents the results of the hypothesis tests, and includes a discussion of the findings related to the literature. The chapter concludes with implications for action and recommendations for future research.

Summary of the Study

The summary of the study is divided into four sections. Beginning with a restatement of the problem and the research questions, the summary contains a review of methodology and a discussion of the major findings.

Overview of the problem. Faculty and staff at *Achieving the Dream* colleges have continued to focus efforts on two student populations: 1) students who test into developmental courses but who cannot complete the developmental sequence; and 2) students who cannot complete gateway (or gatekeeper) courses, which for mathematics is generally College Algebra (Achieving the Dream, 2009). Jenkins, Smith-Jaggars, and Roksa (2009), in a five-year study of Virginia community colleges, found that a mere 26% of those students completed the gatekeeper math course. Researchers at Johnson County Community College (2011b) found similar results, noting an even lower success rate among students who initially tested into the first-level math course; those students had less than a 10% chance of ever completing College Algebra. Research to determine why community college students do not successfully complete gateway courses has become more prevalent. Two schools in particular, Valencia Community College and Westmoreland Community College, recently published updates on their strategies to increase the success of students in their gateway courses. Valencia noted that their initiatives have enabled “over 29,000 students to complete one of the six gateway courses” (Achieving the Dream, 2011b). Instructors at Westmoreland focused their attention on maintaining curricular consistency among their gateway courses, working together to create common course syllabi (Achieving the Dream, 2011b). Instructors at JCCC who participated in this study approached the problem differently, incorporating supplemental sessions into their College Algebra classes in an attempt to improve student success in the college’s gateway mathematics course.

Purpose statement and research questions. The purpose of this quasi-experimental study was to determine the effect of peer-led supplemental project-based instruction sessions for students enrolled in a College Algebra course at a community college. Tutor-facilitated group projects were incorporated into supplemental instruction sessions to ascertain if students would persist longer, be more successful (at least a C in the course), and understand the course concepts more deeply than their peers who were not involved in the supplemental sessions. Further analysis was performed to measure whether students experienced a change in attitude toward mathematics because of the weekly sessions. The results of analysis of qualitative data provided additional information on the likelihood of student success in future mathematics classes because of this experience.

Review of the methodology. Ten sections of College Algebra, five using peer-led supplemental project-based instruction sessions (experimental) and five taught in a traditional manner (control) were compared for persistence (last date attended), success in the class (as defined by at least a grade of "C"), conceptual understanding (analyzed through a Core Question Analysis of a final exam), and change in attitude toward mathematics (using an attitudinal survey). At the end of the 16-week semester, qualitative data on student perceptions of the supplemental sessions were collected through student, tutor, and instructor interviews as well as through online student postings within the JCCC Learning Management System (LMS) shell.

Major findings. The most important finding of this study arose from the disparity between the results of the quantitative analysis (no significant increase in student persistence, success, conceptual understanding, or significant change in attitude toward mathematics) and the results of the qualitative analysis (in describing the difficulty of successfully completing the course, students mentioned the relationship with the tutor and other students as factors in their decision to persist and succeed). The quantitative data suggested the sessions were no more effective than the traditional class by itself, while the qualitative data suggested otherwise. Because enrollment in an experimental section was optional, comparison groups (i.e. experimental versus control) may have differed significantly and it is possible that more students in the experimental classes were relatively disadvantaged as far as being academically prepared for the course. While biographical data on students in control groups was limited, biographical data on students in one of the experimental classes revealed a high percentage of students re-taking College Algebra, some for a third or fourth time. Therefore, some students, who were unprepared for college mathematics, may have opted for one of the experimental classes, hoping this was their best chance of completing the course successfully.

Findings Related to the Literature.

In analyzing findings, several major categories emerged. Those categories included student persistence, successful completion of the course, conceptual understanding of course material, attitude toward mathematics, and embedding group learning within traditional instructions. This section relates those findings to earlier studies.

Persistence. Students in this study who enrolled in one of the experimental classes did not persist significantly longer than students enrolled in one of the control classes. Kuh, Kinzie, Cruce, Shoup, and Gonyea, (2006*)* found that students who engage in educationally purposeful activities are more likely to persist in college. Bean and Metzner (1985) studied attrition for nontraditional students, both at four- and two-year institutions, recommending that institutions "focus first on building student involvement in the classroom through activities such as learning communities" (p. 502). Participating instructors in this study incorporated a learning community approach and designed materials to engage students in educationally purposeful activities; those activities included examining rates of return on investments, and using examples of daily life to describe mathematical functions. In spite of these efforts, quantitative data from this study did not support claims by Bean and Metzner (1985) and Kuh, et al. (2006) that educationally purposeful activities in a learning community setting lead to increased persistence.

Bean and Metzner (1985) noted that the classroom provides commuter students the most contact with the college and with individual faculty members. However, students also benefit from interaction with a mentor or tutor outside of the classroom (Arendale, 2004). The supplemental projects for this study were designed to take advantage of both an increased contact with the instructor and a strong relationship with a tutor/mentor. Instructors had more contact with students due to questions arising from the supplemental projects. Student/tutor relationships went beyond the supplemental sessions; tutors offered extra homework and review sessions to students in the experimental classes (Tutor H, Tutor I, Student SC). Several students claimed they persisted or knew other students who persisted in the class because of the additional help they received from the tutor.

Successful completion. Results of quantitative data analysis from this study indicated that students in one of the experimental sections were no more likely to complete the course successfully than peers who chose to enroll in a traditional section. McClenney, McClenney, and Peterson (2007) argued that the best way for community colleges to improve success rates among their non-traditional students is to increase opportunities for student engagement beyond the classroom. Participating instructors, heeding those words, employed modified versions of supplemental instruction (SI) (Arendale, 2000; Arendale, 2004) and peer-led team learning (PLTL) (Gosser, et al., 2001) in designing the experimental sections. The traditional SI model (Arendale, 2000) does not require student attendance; supplemental project sessions in this study were required, with points counting toward each student's final grade. Tutors in the PLTL model assist with the extra sessions but do not attend the regular class. Tutors in this study attended all of the instructor's classes in order to explain concepts using language consistent with the instruction in the classroom. Thus, instructors designed materials for the supplemental sessions using elements from SI and PLTL deemed most effective for students at this particular community college. In spite of those efforts to engage students beyond the classroom, students were no more likely to earn a "C" or higher in the course than peers who did not participate in the supplemental sessions. Analysis of quantitative data from this study did not provide evidence that would support existing research on student engagement as an effective method of improving community college student success (McClenney, et al., 2007). The results of a similar longitudinal study performed by Ross, et al. (2000), mirrored results in this study; in that case, the researchers provided a rationale for limited effectiveness, noting their experimental group was highly diverse and relatively disadvantaged. Some students, as evidenced by additional survey data collected by instructors (Instructor A; Instructor E), may have opted for one of the experimental sessions because of previous experiences of failing College Algebra. Perhaps students in one of the experimental sections were academically disadvantaged when compared to peers in one of the control sections.

Boylan and Saxon claimed active learning methods are critical for improving student success among adult students because, "These students have already been exposed to the typical lecture, discussion, drill and practice approaches used in high school courses and college remediation and they have not worked" (as cited in Boroch, et al., 2010, p. 71). Qualitative data collected in this study supported existing research on the effectiveness of active learning methods. Students who posted comments about their experiences with the supplemental sessions noted the helpfulness of working with other students to prepare for exams and to work on homework problems (Student EM; Student JW; Student AZ). Active learning opportunities in the supplemental sessions for this study, which spanned a twelve-week period, allowed students to explore topics in mathematics while working collaboratively with other students in the group. For each of the four major session topics, students spent the first week analyzing the problem, creating strategies to solve the problem, and assigning various parts of the problem to students in the group. Students spent the second week working together on what they had learned the first week. The third week, students presented their conclusions to other students in the class. This design encouraged students to engage with peers throughout all twelve weeks of the supplemental sessions; students continued that engagement as they prepared for the final exam, scheduling extra study sessions with each other and with the tutor (Student SC; Student JW; Student CS; Tutor H; Tutor I). Qualitative data provided evidence that once formed, student connections continued beyond the twelfth week.

Results of analysis of qualitative data from this study also provided insights into students' perception of what being successful in mathematics means. In interviews conducted by the researcher, students complained when the supplemental sessions did not lead to immediate results. One student explained it this way, "Students were thinking 'I got a D on the last test and that shouldn't happen if I am doing all of this extra work'" (Student SC). Students, in interviews and postings, seemed to measure success through one parameter: grades, believing the extra sessions were a waste of time if those sessions did not translate to a higher exam score. While tutors and instructors hoped that success in College Algebra would go beyond a higher grade and would potentially lead to a love of mathematics (Tutor H; Instructor B), many students viewed success as merely getting through the class (Student DD; Student JW; Student SC; Student VO).

Conceptual understanding. Quantitative results of the Core Question Analysis (CQA) of final exams indicated that students in one of the experimental classes were no more likely to master course concepts, when compared to peers in one of the control classes. Ladson-Billings (1997) explained the need to require students to "not merely memorize formulas and rules and apply procedures but rather to engage in the *processes* of mathematical thinking" (p. 697). Instructors designed the supplemental projects to give students opportunities to engage in the process of mathematical thinking by exploring problems that went beyond concepts covered in the homework. As one of the original creators of the session materials explained, "I wanted to see if we could create other things besides more skills repetition. I wanted to see if those things would have an effect" (Instructor B). During the required supplemental sessions, the students had neither time to work on homework problems, nor time to memorize rules and procedures. The session materials challenged tutors and students alike.

Analysis of quantitative CQA data did not provide evidence that an emphasis on mathematical thinking translated into a deeper conceptual understanding of the course concepts. An analysis of qualitative data might explain why that phenomenon occurred: some students did not see a connection between what took place in the supplemental sessions and exam questions (Student CS; Student VO; Student WL). Even an analysis of questions strongly correlated with session topics, such as exponential growth and zeroes of polynomial functions (see Appendix J), showed no significant difference between control classes and experimental classes in a CQA. Boaler (1998) found that "the act of using mathematical procedures within authentic activities allowed the students to view the [mathematical] procedures as tools they could use and adapt" (p. 59). The quantitative data showed little or no evidence of that phenomenon occurring, since students seemed unable to adapt procedures learned during session activities to exam questions.

Student interviews provided additional insight into students' perception of understanding, through common phrases students used to describe that understanding. Several students characterized the sessions as helping them "know which formula to use" (Student CS; Student JW). Another student, when asked if she thought the sessions helped her on the exams, explained, "I don't know if the sessions specifically helped me figure out how to do something. But it definitely helped me understand it better. Math is more of not if you know how to do it; it's more about can you do the equation the right way" (Student SC). These comments provided evidence that students' perception of conceptual understanding is often defined by whether they know which formula to use. Ladson-Billings (1997) noted that, "Mathematics teaching in our schools emphasizes repetition; drill; convergent, right-answer thinking; and predictability" (p. 699). Student comments, both from online postings and interviews, seemed to confirm that many students see mathematics in a limited scope, with an emphasis on using the right formula. Although one of the goals of the sessions was to help students advance beyond right-answer thinking and predictability, student comments did not provide evidence of that phenomenon occurring.

Attitude toward mathematics. Results of the quantitative analysis of attitudinal data from this study found a small positive change in attitude toward mathematics, in two of the five classes, which supported research conducted by Ma (1999). During the fall semester, Instructor B noted a significant change in Q1—I believe I can learn math concepts through group projects—as well as a significant change in Q7—I anticipate using math in my future career. During the spring semester, Instructor C also experienced a significant change in student attitudes on Q7. However, results of further analysis of attitudinal data did not provide evidence that students found mathematics more fun, worthwhile, or believed they had more confidence because of their experience in the supplemental sessions.

While analysis of quantitative data yielded little evidence of change in attitude, online postings and student interviews provided examples of attitude changes that may have led to behavioral changes. Kilpatrick, Swafford, and Findell (2001) described five indicators of mathematical proficiency, including productive disposition, which the authors defined as "the student's habitual inclination to see mathematics as a sensible, useful, and worthwhile subject to be learned, coupled with a belief in the value of diligent work and in one's own efficacy as a doer of mathematics" (p. 107). Student comments, through interviews and postings, validated an approach to teaching mathematics focused on applications. Student JW explained, "Most people are not looking to use this stuff unless they are going into some kind of special engineering. The thought that we were going to have to sit through another hour of it was just kind of a downer at first. But once we started doing those sessions, they were actually more fun than anything." The researcher and instructors designed one of the workshop topics around the concept of exponential growth. Using an unfolding problem design (Millis and Cottell, 1998), instructors created an open-ended problem that asked students to invest a fixed amount of money for the instructor's college fund. Students spent the first week of the activity asking questions about unknown information. In the initial information provided to students, instructors did not provide interest rates or compounding details; it was up to the students to gather that information from area banks. In online postings about this activity, several students used the words "surprised" and "amazed" when describing their reaction to this topic. Prior to this activity, many students had no idea what interest rates were.

While some students appreciated the focus on real-world activities provided by the session materials, other students seemed only to care about how the sessions would affect their grade in the class. One student described a colleague as "up and down;" the student had a positive attitude if she "got it" but was very negative if she did not "get it." Student CS, when asked about things in the session that made it difficult to learn, confirmed that notion: "When people in class would say, 'oh, that's easy.' For me it wasn't easy and I was kind of frustrated because I wish it was that easy for me." Student SC explained: "I think it all depends on how well you did in the class–how you did your homework–stuff like that." Rather than getting frustrated when he did not understand what was occurring in the sessions, student JW used a different approach. "Hearing it with everyone else's input, even if I didn't completely understand it, I kind of went with it. I thought if I need to understand that more later on I will go back to it."

Embedding group learning within classroom instruction. Cooperative learning theorists believe that learning is inherently social (Millis & Cottell, 1998). Results from the analysis of qualitative data from this study indicated that some mathematics instructors have a difficult time structuring classrooms to promote social activities. Often, these instructors describe not being able to cover all of the material in the course and regret not having more time for group activities. As Instructor D stated:

> The College Algebra curriculum is so full that it is hard to get everything done that we want to get done, and so doing some of those connections and some of those fun things, we don't really get to do that very often. Our fun consists of getting them into groups to talk about things that I am explaining, as opposed to them discovering things for themselves."

Prosser and Trigwell (2010) recommended that researchers focus on creating contexts that make learning possible, which includes creating spaces and opportunities where students can learn from each other. Students, some of whom initially complained about having to attend a supplemental session, uniformly praised the group setting. Student SC's comment summarized what many other students posted.

> I think the most benificial [sic] part for me has just been getting to know my class-mates. It's made it much easier to study with them and approach them outside of class since we've gotten to know each other during these sessions. I don't feel that I get to know students as well as I did in this class, and I attribute that to the sessions after class.

Tutors and instructors also commented on the sense of community that arose because of the sessions. Some students explained they did not believe they would have made it through the class without the help of the groups. Tutor H told a particularly poignant story.

> There was a student in the spring and within the first week or two of school she said to me that she had taken College Algebra before at another school and she

> said, “I am not good at this, I can’t do it, I am going to fail”; you know, all those kind of negative things. As the semester went along and as she did more projects and I also did those study groups, a combination of all those things and her working hard at it too, I think she nearly got an A. I know she got a B. That’s a success story when you take somebody who says, “Oh my God, I know I am never going to be able to do this” doom and gloom and to nearly get an A. She was happy to get a B. That’s what I think (personal communication, August 17, 2011).

As Instructor E explained, “Students can learn from each other. I wasn’t there [in the supplemental sessions] and they learned anyway.”

Conclusions

Implications for action. Community colleges continue to experiment with educational innovations designed to improve student learning (Achieving the Dream, 2010). At the same time, these innovations can be costly, taxing scarce resources. The results of this study provide evidence that community college students find it difficult to devote additional time beyond the classroom, unless that time is spent working on activities that the student believes will directly affect his or her grade, such as homework problems or exam reviews. Rather than creating sessions *in addition to* the classroom work, community college instructors should consider allocating time *within the classroom setting* to work on supplemental projects. Community college students, many of whom work full-time jobs and take care of families, do not believe they can devote even more time to activities designed to promote deeper thinking. While supplemental projects may have a significantly positive impact on students in a four-year residential setting, this study provided little empirical evidence that students in a community college setting will be more successful by taking part in a project-based setting outside of the classroom.

The results of this study also demonstrated the paradox mathematics instructors at a community college face: on the one hand, instructors recognize a need to improve success rates in their gateway mathematics courses; on the other hand, instructors experience resistance when they attempt to restructure their classes in a more interactive and project-based format. Sometimes that resistance stems from a curriculum that is so dense that instructors do not believe they will have time to work on project-based activities with the classroom setting (Instructor B; Instructor D). Other times, difficulty arises from instructors' inability to give up control. Instructor D expressed personal challenges ceding control, stating, "…the sessions were very difficult for me. Part of the reason they were very difficult for me was because I want to control every aspect of what goes on. So it was very difficult to turn them over to the tutor." Boroch, et.al, (2010) argue that one way instructors can give up control is by focusing on student learning rather than on the instructional delivery noting "the most important role of the instructor is the design of the instructional experience in order to provide structure and goals, even if he or she relinquishes control" (p. 71). Community college instructors must continue to examine how much material should be taught in College Algebra, paring curriculum where possible, allowing their students time for more project-based activities. Community colleges must also recognize the need to design and deliver professional development activities, designed to help instructors move beyond a skills-based teaching approach, moving instead to an approach that focuses on the learner (Cerbin & Kopp, 2011).

Finally, community colleges should follow the lead set by Kansas State University (Manspeaker, 2011) and create more learning options for students in gateway mathematics courses, matching those options to student learning styles. Researchers at community colleges should continue to identify instructional settings where students with particular characteristics will be successful, and revise policies to require students to enroll in sections where chances of success will be highest.

Recommendations for future research. The results of this paper provide evidence for the need to continue to study the effect of project-based supplemental sessions in gateway mathematics courses. An analysis of quantitative data showed no gains in persistence, successful completion, understanding of key course concepts, or an improved attitude toward mathematics. However, the analysis of qualitative data painted a very different picture: students stated they would not have persisted or been successful in the course without the connection to the tutor and to other students. Future research into this dichotomy should include studies to test the effect of group activities embedded into a College Algebra classroom, rather than appending those collaborative activities into a supplemental setting. Instructors at four-year residential colleges and universities might consider studying the effect of project-based supplemental sessions for their entering students. The positive outcomes students experienced in this study could translate to deeper thinking, greater collaboration, and increased graduation rates for students at four-year colleges. Four-year college instructors may wish to replicate this research to determine if the setting (i.e., non-community college) is important to the results.

The fact that an analysis of data from the study showed no significant increase in conceptual understanding of key course concepts (as measured by CQA) may simply be an indictment of the limitation of using final exams to measure student learning. While students taking part in the project-based supplemental sessions worked collaboratively on real-world mathematical problems, all twenty-five problems on the JCCC College Algebra final exam were skills-based questions. The final exam did not contain questions that included real-world applications, nor did the final exam require students to use any specific problem-solving techniques learned in the supplemental sessions, such as teamwork, collaboration, or oral presentations. In other words, students participating in the supplemental sessions learned a novel way of approaching mathematics but those students demonstrated their understanding of mathematics using the same assessment techniques those students had always experienced. Further research, employing assessment instruments designed to measure students' ability to think critically, work collaboratively, and communicate mathematics, would help to determine if these kinds of project-based sessions provide benefits for students beyond performance on a standardized exam.

Data from this study underscore the disconnect occurring between curricula designed to encourage students to be better mathematical thinkers and curricula designed to raise the number of students who perform well on standardized math tests. Mathematics educators find themselves in a tenuous position: they must create a curriculum and instructional pedagogy that improves students' ability to work think critically, work collaboratively, and communicate effectively while, at the same time, implementing instructional strategies to increase the number of students who successfully complete gateway courses. That would be challenging in normal times. It is even more challenging as resources continue to become scarcer. Research on effective practices to help move instructors improve success rates while, at the same time, designing activities that make mathematics more meaningful, should be encouraged.

Concluding Remarks

On August 25, 2011, a *New York Times* editorial, "How to Fix our Math Education," (2011) began with a description of the "widespread alarm about the state of our math education" (Garfunkel and Mumford p. A23). The authors argued that this alarm is unfounded because it assumes there is a "single established body of mathematical skills that everyone needs to know to be prepared for twenty-first century skills" (Garfunkel & Mumford, 2011, p. A23). Many community college algebra instructors believe they do teach a single established body of mathematical skills, which includes graphing functions, finding zeros of polynomials, solving exponential equations, and solving linear systems of equations (Johnson County Community College, 2011d). Garfunkel and Mumford (2011), however, ask an important question in their editorial: how often do most adults encounter a situation in which they need to solve a quadratic equation? While the mathematics community continues to argue the merits of teaching the quadratic formula, the rest of the world seems to have adopted new criteria for necessary skills in the twenty-first century, which include critical thinking, collaboration, and effective communication (Wagner, 2008).

Perhaps a large part of the problem is that community college mathematics instructors have continued to search for answers to why students cannot solve quadratic equations, rather than asking if students need to know how to solve quadratic equations. Although the supplemental project activities in this study did not contribute to significantly higher persistence, success, understanding of key course concepts or improvement in attitude toward math, evidence exists that these activities provided long-term benefits for students, including better critical thinking and problem solving abilities, an increased awareness of the importance of collaboration, and techniques to become better communicators. While these kinds of supplemental sessions may not move the needle on the next TIMSS study, evidence indicates they may do something even more important: provide students with the new skills needed for college, career, and citizenship.

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Appendix A: IRB Approval Letter

3-31-2011

Jeff Frost

School of Education Graduate Department

Baker University

RE: IRB: BU-2011-04, The Effectiveness of Supplemental Projects on Community College Student Learning in a Gateway College Mathematics Course

Dear Mr. Frost:

The Baker University Intuitional Review Board (IRB) has reviewed your research project application (BU-2011-04) and approved this project under the Expedited category. As described, the project complies with all the requirements and policies established by Baker University for protection of human subjects in research. Unless renewed, approval lapses one year after approval date.

1. A Project Status Report must be filed with the IRB annually for continuation.
2. Any significant change in the research protocol must be reviewed and approved by the IRB prior to altering the project.
3. Any change in the investigator(s) named in the original application must be reviewed and approved by the IRB prior to altering the project.
4. Any injury to a subject because of the research procedure must be reported to the IRB immediately.
5. When signed consent forms are required:

a. the primary investigator must retain the forms until filed,
b. consent forms must be filed with the OIR with the annual report,
c. the subject must be given a copy of the form at the time of consent.

6. If this is a funded project, a copy of this letter must be with the grant file.

The Office of Institutional Research (OIR) must be notified when this project is completed or terminated. As noted above, you must provide an annual status report to receive approval for maintaining your project. If your project receives funding which requests an annual update, you must file your annual report at least one month prior to the annual update.

Thanks for your cooperation. If you have questions, please contact me.

Sincerely,

William R. Miller, Ph.D.

Chair, Baker University Institutional Review Board

Appendix B: IRB Application

IRB Request

Date ____November 11, 2010__________________________

IRB Protocol Number_________________

(IRB use only)

I. Research Investigator(s) (students must list faculty sponsor first)

Department(s) ___________________

Name Signature

1. ______Jeff Frost ______________ ______________________

Principal Investigator

2. __Dr. Anne Daugherty_____ ______________________ ____ Check if faculty sponsor

3. ____________________ ______________________ ____ Check if faculty sponsor

4. ____________________ ______________________ ____ Check if faculty sponsor

Principal investigator or faculty sponsor contact information: Phone __(913) 469-3104_______________________

email _____jfrost@jccc.edu____________________

Mailing address of Principal Investigator:

Math Division

Johnson County Community College

12345 College Blvd.

Overland Park, KS 66210

Expected Category of Review: __ Exempt _X_ Expedited __ Full __ Renewal

II: Protocol Title

The Effect of Supplemental Projects on Community College Student Learning in a gateway college mathematics course

III. Summary:

The following summary must accompany the proposal. Be specific about exactly what participants will experience, and about the protections that have been included to safeguard participants from harm. Careful attention to the following may help facilitate the review process:

In a sentence or two, please describe the background and purpose of the research.

The purpose of this research study is to determine the effectiveness of supplemental projects in helping students understand and master the concepts of College Algebra. A student selected for study will be one of 6-8 students who will be asked to take part in scheduled interviews and focus groups during late spring/early summer of 2011.

Briefly describe each condition or manipulation to be included within the study.

The study will examine students' own observations of what helped them be successful or not successful in their College Algebra class.

What measures or observations will be taken in the study? If any questionnaire or other instruments are used, provide a brief description and attach a copy.

In January 2011, all students eligible for interviews will complete a math attitude survey (see attached). Surveys will be analyzed in order to identify students with strongly negative attitudes towards mathematics. Shortly before the end of the spring 2011 semester, 6-8 students will be selected for in-depth interviews. The interviews will allow participants to describe aspects of the College Algebra class that led to their success or kept them from being successful. Four of the students chosen for study will have been in the experimental class (i.e., those students enrolled in the class with supplemental projects); the other students chosen will have been enrolled in the traditional class (i.e., no supplemental projects). The first interview will be taped and the researcher will transcribe the tapes. Once the tapes are transcribed, the tapes will be destroyed. The second interview will occur a month or so after the first interview and will be focused on themes that arose during the first round of interviews. The third activity will be a focus group where the 6-8 students chosen will have the opportunity to hear the stories of the other students. The students will then be given a chance to reflect on the other stories they have heard and add anything to their stories, if they desire to do so.

Will the subjects encounter the risk of psychological, social, physical or legal risk? If so, please describe the nature of the risk and any measures designed to mitigate that risk.

There is no risk, neither psychological, social, physical, nor legal. The students may opt out of the research at any time.

Will any stress to subjects be involved? If so, please describe.

The study has been designed so that there will be no stress to any of the subjects.

Will the subjects be deceived or misled in any way? If so, include an outline or script of the debriefing.

No. The open-ended questions allow the students to reflect on their learning and to tell their stories in their own words.

Will there be a request for information which subjects might consider to be personal or sensitive?

There will be no request for any sensitive or personal information. Students may share stories that are personal in each of their interviews but each student will have an opportunity to review his/her story prior to that story being included in the research. All students will remain anonymous.

If so, please include a description.

Will the subjects be presented with materials which might be considered to be offensive, threatening, or degrading? If so, please describe.

No.

Approximately how much time will be demanded of each subject?

The first interview will last about one hour. Once the initial interview is transcribed, the narrative will be sent to the interviewee for his/her review. The amount of time the interviewee needs to review that narrative will be dependent upon the person; however, it is not expected that this review will require more than 30 minutes. The second round of interviews will also last one hour and the student will again be given a chance to review that narrative. The third round will be a focus group and that should last no more than one hour. It is expected that each student will spend about 4 hours total.

Who will be the subjects in this study? How will they be solicited or contacted? Provide an outline or script of the information which will be provided to subjects prior to their volunteering to participate. Include a copy of any written solicitation as well as an outline of any oral solicitation.

As noted above, students selected for this research will be chosen from a group of students identified with negative attitudes toward mathematics. Students chosen for study will have first completed a math attitudinal survey; the survey was developed by Rachel Manspeaker at Kansas State University and has been tested for validity. The surveys asks students to respond to statements and tell how much they agree or disagree with a statement. For example, one of the statements in the survey asks to tell whether they agree or disagree with this: *Being good at mathematics is something a person is born with, like being left-handed.* Dr. Manspeaker has been able to validate a correlation between certain responses to statements with a negative attitude toward mathematics. Once the group of students with a negative attitude toward mathematics has been identified, those students will be asked if they would like to participate in interviews. The solicitation will be:

You have been selected for possible inclusion in a math research study. The purpose of the study is to better understand the factors that help students achieve success in math classes. If you are interested in participating, please send an email to Jeff Frost at jfrost@jccc.edu. Please write "Research Study" in the subject line and include in the body of the message the best way for the researcher to contact you. Your participation will require three approximately one-hour interviews sometime between April and June of 2011. Thank you for your consideration. We look forward to hearing from you!

What steps will be taken to insure that each subject's participation is voluntary? What if any inducements will be offered to the subjects for their participation?

After each interview, students will be given a $5 gift card to the coffee show at JCCC (Java Jazz). Students will be told from the outset that their participation is voluntary and that they may opt out at any time.

How will you insure that the subjects give their consent prior to participating? Will a written consent form be used? If so, include the form. If not, explain why not.

See attached Informed Consent form.

Will any aspect of the data be made a part of any permanent record that can be identified with the subject? If so, please explain the necessity.

No.

Will the fact that a subject did or did not participate in a specific experiment or study be made part of any permanent record available to a supervisor, teacher or employer? If so, explain.

No.

What steps will be taken to insure the confidentiality of the data?

Any information obtained during this study which could identify the individual student, including audio recordings or hand-written notes, will be kept strictly confidential. The information used in this research will be stored in a locked cabinet in the investigator's office and will be seen only by the investigator and a research auditor during the study. The audio recordings will be destroyed as soon as transcriptions are completed and verified by the auditor to represent the content of the tapes. All other materials will remain in the locked cabinet in the investigator's office for three years after the research is completed. The information from this study will be analyzed, interpreted, and reported through a case study as a student research document.

If there are any risks involved in the study, are there any offsetting benefits that might accrue to either the subjects or society?

There are no risks. The benefits of the study could help us make better pedagogical decisions.

Will any data from files or archival data be used? If so, please describe.

No.

Appendix C: Baker University Informed Consent Form

BAKER UNIVERSITY

SCHOOL OF EDUCATION

INFORMED CONSENT FORM

IRB#

BU-2011-04

Identification of Project (Project Name): The Effectiveness of Supplemental Projects on Community College Student Learning in a Gateway College Mathematics Course

Purpose of Research and Completion Date: Your participation in this research study will help us understand activities that lead to student success as well as barriers that keep students from being successful in math classes. All research will be completed by the end of summer, 2011.

Procedures: There will be three scheduled interviews, each lasting approximately one hour. The interviews will take place during the spring/summer of 2011. Each interview will be taped and the researcher will transcribe each tape. Once the transcription is complete, a copy of the transcript will be sent to you for your review. You will have an opportunity to make any changes to the transcript before the next interview.

Risks and/or Discomforts: There will be no risks should you decide to participate. We will conduct the interviews in a campus location that will be in a comfortable setting to make each interview as enjoyable as possible.

Benefits: Across the nation, College Algebra is one of the most difficult courses for college students to successfully complete. We believe your participation in this study will us help identify factors that make students more successful in College Algebra. We also believe you will benefit by having a focused opportunity to reflect on your learning in math.

Confidentiality: Any information obtained during this study which could identify you or your instructor, including audio recordings or hand written notes, will be kept strictly confidential. The information used in this research will be stored in a locked cabinet in the investigator's office and will be seen only by the investigator, his advisor (the secondary investigator) and a research auditor during the study. The audio recordings will be destroyed as soon as transcriptions are completed and verified by the auditor and the interviewee to represent the content of the tapes. All other materials will remain in the locked cabinet in the investigator's office for three years after the research is completed.

Compensation: With the exception of a gift card from Java Jazz, there will be no compensation for participating in this research.

Opportunity to Ask Questions: You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. You may call the investigator at any time at (913) 221-1160. If you have questions concerning your rights as a research subject that have not been answered by the investigator or to report any concerns about the study, you may contact Baker University's Institutional Review Board.

Freedom to Withdraw: You are free to decide not to participate in this study or to withdraw at any time without adversely affecting your relationship with the investigator or Baker University. Your decision will not result in any loss or benefits to which you are otherwise entitled.

Consent, Right to Receive a Copy: You are voluntarily making a decision whether or not to participate in this research study. Your signature certifies that you have decided to participate having read and understood the information presented. You will be given a copy of this consent form to keep.

_________ Check if you agree to being audio recorded during the interview.

Signature of Participant:

______________________________ ____________________

Signature of Research Participant Date

Name and Phone Number of Investigators

Name: ____________________________________ Phone: 913 221-1160

Appendix D: Attitude Survey

As part of our *Achieving the Dream* strategy to improve instruction, the math division at JCCC is collecting student data on attitudes toward learning mathematics. There are no right and wrong answers to this survey, but your answers may help us determine which type of math classes will help you learn best. Survey questions 3 – 10 were developed by the math department at Kansas State University; the Center for Quantitative Education at KSU has granted JCCC permission to use those questions.

Please place an **X** in the box of your choice.

	Strongly Agree	Somewhat Agree	Ambivalent	Somewhat Disagree	Strongly Disagree
1. I believe I can learn math concepts through group projects.					
2. Mathematics is a worthwhile subject to learn					
3. Being good at mathematics is something a person is born with, like being left-handed					
4. It is very important to me that I attend a small class where the instructor can keep track of my progress.					
5. If I don’t know how to do a math problem, looking back at my class notes or the textbook is helpful.					
6. I usually only understand a new concept after working with a friend or a tutor.					
7. I anticipate using math in my future career.					
8. I am pretty confident in my math skills.					
9. If I miss class, I can learn the material on my own or with a tutor.					
10. Mathematics classes can be fun.					

Appendix E: Interview Questions

Phase one questions for students:

1. Could you describe your experiences in math classes prior to this class?
2. Could you describe your experiences in this math class?
3. Are there things that helped you learn? If so, what were they?
4. Are there things that made it difficult for you to learn? If so, what were they?
5. Has this class changed your attitude toward math in any way? If so, how?
6. Has this class changed your career plans in any way? If so, how?

Questions for tutors

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?
2. What did you learn by working with the instructor? Will you continue to use some of what you learned?
3. What did you learn by working with the students? Will you continue to use some of the things you learned?
4. What were some of the positive things you heard about the sessions from the students?
5. What were some of the negative things you heard about the sessions from the students?
6. Did you see examples of students who succeeded because of the sessions? If so, what were they?
7. Did you see examples where students were not successful because of the sessions? If so, what were they?
8. Is there anything else you want to share about your experiences with the sessions?

Questions for instructors

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?
2. What did you learn by working with the other instructors? Will you continue to use some of what you learned?
3. What did you learn by working with the tutor? Will you continue to use some of the things you learned?
4. What were some of the positive things you observed or heard about the sessions from the students?
5. What were some of the negative things you observed or heard about the sessions from the students?
6. Did you see examples of students who succeeded because of the sessions? If so, what were they?
7. Did you see examples of students who were not successful because of the sessions? If so, what were they?
8. Is there anything else you want to share about your experiences with the sessions?

Appendix F: Student Interviews

CS, African-American female, completed all course for a BA except 6 hours of mathematics, repeating College Algebra

Phase One:

Interviewer: Introductory script (explaining the permission form)

Interviewer: Could you describe for me your experiences with math classes prior to this one?

CS: My previous experiences with other math courses is that I had a hard time understanding what we did when I got home. When I actually went to do my homework or to study I was having a hard time actually remembering. Like, ok, what's the next step? Or, this is what you do here. And I have always had that problem. And I have also taken a few online courses and I also feel like that was a difficult way for me to learn. That was my downfall because I didn't have someone else saying here's exactly how we are going to do it. This course that I did take I felt that the Professor did a great job of helping students really understand what the steps were. The sessions were fun and also very educational. So it was just a whole different type of learning. And I really enjoyed it. This was the best that I have done in any math course.

Interviewer: Describe your experiences in this math class.

CS: He did a wonderful job. The power points really helped me learn. He was a very nice professor. Any time I had a question he would email you. He was very reliable. He explained – if you didn't understand one way he would say, here's another way to think about it. If you didn't do good on this quiz here's another quiz. The same exact thing but maybe different wording or numbers. I'll go over with you what you got wrong so you can figure it out on your own.

Interviewer: What things helped you learn?

CS: I have never been in a class before where you had to take a group quiz before. It made me feel like, not only was it important for my own grade but I needed to make sure I knew the steps and I needed to have the correct answer because I don't want other people to think I am not contributing to the group. Or am I giving the wrong answer.

Interviewer: Are there things that made it difficult for you to learn?

CS: When people in class would say, "oh, that's easy." For me it wasn't easy and I was kind of frustrated because I wish it was that easy for me. But that was something that was outside of my control.

Interviewer: Has this class changed your attitude toward math in any way? If so, how?

CS: It definitely did. I have taken this class 4 times and I have had so much frustration. I have had so many tears and just in me showing improvement through personal gain. I feel like I was able to accomplish more this time, and I feel like I can do it, rather than me sitting there about to take and exam and I am like, I just start to break down. I feel like I am going to get a bad grade.

Interviewer: Has this class changed your career plans in any way? If so, how?

CS: No.

Phase Two:

Interviewer: How is it going?

CS: I understand everything. I get it and I have been communicating with my teacher. We have been emailing back and forth. Everything has been really good.

Interviewer: You have liked your teacher?

CS: Not really. I know that for example, I emailed her on Friday and I just heard back from her today. So it is kind of one of those things but I am doing everything I can do as a student. I talk to her in class I talk to her after class. I am doing my part. I am just trying to make myself learn. After class I am going home and doing the homework. I am not waiting for two days to go by and it is not fresh anymore because I know that I can't do that. I have been reading the textbook so not only am I hearing what she is saying and taking my own notes but I am looking at directions and everything too. I am hoping I can knock it out and save my grade and then the final is cumulative so I just have to review everything.

Interviewer: You said you are no longer waiting two days to get started. Tell me what you have learned about the way you learn math.

CS: Like I said I can't wait a couple of days after. Another thing is that I need to review the information kind of like right away. Even if I am not doing my homework right after class, if I am doing it that night or maybe the next morning I need to go back and I need to look at everything so then I can like, okay, I can understand it or I know what I need to review before I can start my homework. And I not getting frustrated by one problem and I am saying, "I need a break" and then a break turns into a couple of days. Pretty much just getting on it right away making sure that all my questions I have I am asking students in class if I don't understand what the teacher is saying. There are people who really do love math and they don't have a problem helping and so one of those is actually in my class and she sits by me which is, you know, good for me (laughter). And so she is always like, "do you want to check answers?" And I am like, "of course I want to check answers." And it also motivates me that I get the right answers so she is not depending on me for answers. So it feels good that I know I am contributing.

Interviewer: Did the project sessions that you did make any difference in your belief that working with others could help you learn? If so, how? Was there a connection made between you and the teacher, you and the tutor, or you and other students?

CS: At the time, no. At the time I just thought, I am just sitting here. I am learning better in the class. I just kept telling myself. But now I am just sitting in a class by myself. I don't have to work in any groups but I get a homework assignment that I have to turn in before you leave and she says you can work with others if you want or you can work by yourself if you want. And so, in the past I kind of just sat there and everyone else said let's get this figured out so we can get out of here. But I am not that fast so I felt like I was hindering others. But since we have an option of working with someone else, I know need to get motivated to learn it and not just assume that they want to get out of here so I have a free ticket on my homework. That's just the reality of it. It's embarrassing to say that (laughing).

Interviewer: What finally clicked that told you that you couldn't wait to do math and instead, had to work more regularly?

CS: Honestly, I am going to be honest (laughing). There's a girl in my class and she lived in Lawrence too so we would get together and she said she was not good in math. She told me we are going to work together, we are going to be buddies. Well she depended on me and it was the first time I had ever been in a situation where someone was asking me, what answer did you get? Nobody ever asks for my answer. That just really made me feel like, that was too much pressure for me. I am really not confident already but I felt like if you got the answers wrong then I felt bad. So she actually dropped the course. It was too much. And we she dropped it, I don't want to say it was a relief but I knew that it was all me from here on out. So that's when I kicked in and started doing my homework right away. I started trying to make myself understand because there is no one else to rely on but myself. And as many times as I have taken math that has never happened before. But now it is finally here. I get it. I get that I can't wait. If I have a test next week I have to start looking at it a week before. I don't have the skills to get 100% and not do any homework.

Interviewer: It has been hard to balance another math class with a hectic schedule. My plan is to when I get down to Florida I am just going to totally focus on the math thing. I am trying to get it done before August 1st but it is not going to happen.

JW, returning adult, male, Caucasian

Phase 1:

Interviewer: Introductory script (explain the permission form)

Interviewer: Could you describe for me your experiences with math classes prior to this one?

JW: Up through Algebra I, I made straight As in math. But once I hit Geometry, I got a D in Geometry and a D in Algebra II. After that I just fell apart.

I originally started with College Algebra. Probably a month into it I realized I just wasn't doing well at all, so I dropped out of it. I went into the pre-requisite course for it, which was an intro to College Algebra. I made a B in that class and I breezed right through it, but again went back to the College Algebra, and still had issues with it. I dropped it I think two other times before this most recent time. I did pass it this time but I could not have passed it without the help of those group sessions that we did. And the reason I say that is because it gives you more real-world feel scenarios of how to use a particular formula. I think just seeing it in a book and listening to how an instructor says it, I didn't grasp the concepts behind it until I saw those real-world scenarios when we were dealing with the stock market trends, and so on and so forth. Especially playing poker for a living I can do all the basic math in my head, literally, that's all I do. But once you get into someone else's formula is what threw me off.

Interviewer: Could you describe your experiences in this math class?

JW: The instructor really helped. If you needed help on a one-on-one basis the instructor would always help. Myself, I like to get as little help as I can, I like to do things on my own if I can, but if I had any kind of question or concern, no matter if it was through email, she would always respond right away. She would attempt to give me the feedback that I needed in order to get through the session. And so did the tutor. He was extremely helpful as well. I tried to go to the Math Resource Center as often as possible to try to get myself through this class. But it is hard being 33 years old, to actually take myself aside and go sit in the Math Resource Center. I mean, I was one of the oldest people in the room and it made me feel less, you know? Because I am not at that young student age any more. I think my learning greatly benefitted by those extra sessions. Like I said, I know I could not have finished that class without those sessions. They really did help me. And when I first sat in the class and heard about those sessions I thought, "wow, more class? We already have a 3-hour class and then we are going to have to sit through another hour after this?" But they really were beneficial once I started sitting in them. They were more fun and real-life scenarios.

Interviewer: What things helped you learn?

JW: I would say when it came to seeing how some of the formulas related to the math, I think we dealt with the stock market, learning the interest versus principal. We had a set amount of money and we were setting it up for a college fund for your child. We had to try to find a bank that had the highest interest rate when we stuck that money in - what the money would turn into, say five or ten years down the road. If the interest was compounded quarterly, continuously, yearly, you know, however the interest was compounded. We had to come up with the best scenario to invest that money. That was a huge benefit to me. Every type of formula that we used we went into some small group session to learn how to relate that formula to whatever that topic was in the real world.

Other than that one topic, I don't know that I can think of any others off the top of my head but I know that one was beneficial.

Interviewer: Are there things that made it difficult for you to learn?

JW: No. The only thing is I wish I would have done this years ago and stuck to it. I was just an idiot in my 20s and I didn't really care about school. I didn't really grasp it. Five to ten years ago it was a lot easier to get a job or a career without education. Now it's not even guaranteed. I know attorneys and accountants that can't find a job right now. Even with Master's degrees. I don't feel so bad, but I do because I am so far behind.

Interviewer: Has this class changed your attitude toward math in any way? If so, how?

JW: I think before, I never would have considered taking any other math class. Now, I have thought about taking a statistics class for fun. I don't know why anyone would do that (laughs), but I have considered it just because of the feedback I got from my instructors. They kept pushing me saying, "why don't you take a statistics class?" Especially the tutor. Because he also plays poker and he knows that it helps him and thought it would be beneficial to me, as well.

Interviewer: Has this class changed your career plans in any way? If so, how?

JW: No. I don't see myself going into something that is going to be heavy in math. Basic math, maybe. I can do that all day long in my head.

Phase Two:

JW Questions from Phase 2:

Interviewer: You said you went back and took the pre-requisite course. Did you ever see any kind of connection between the math you use in your world and that course?

JW: No, I can do basic math in my head all day long and statistics in my head. But when it comes to so many different formulas, and when to use those formulas, it's what really got to me.

Interviewer: Would you talk about the relationships you made during the class?

JW: I guess the only real relationship I made was with the tutor. We had a common bond with the poker. We were poker players. He does it more for fun, every now and then, whereas I have done it for a living the past three years. Not by choice but I can't find another option that pays me more without a degree. The tutor was the only after-class relationship. I have never been really big on associating with other people in my class unless we needed some kind of group session.

Interviewer: How did those sessions go for you?

JW: Everyone in the class was great. No one really had anything negative about the class. Except quite a few of us in the beginning when we heard we would have another hour after the class - to sit through more math. No one would want to do that unless you wanted to be a math teacher.

Interviewer: Would it have been better for you if the sessions would not have been in addition to the class but instead would have been integrated into the class? Would that have made it more fair for you?

JW: I can't say it was unfair. They were more beneficial than anything. It was just hearing that we were going to have another hour. Most of us were just thinking, "okay, we just have to get through this class and get this over with." Most people are not looking to use this stuff unless they are going into some kind of special engineering. The thought that we were going to have to sit through another hour of it was just kind of a downer at first. But once we started doing those sessions, they were actually more fun than anything. I mean, I didn't feel like I had to have the right answer each time we did one of those sessions, because there were more than just myself to put it together. I can say rarely did anyone get anything wrong because so many people were so helpful.

Interviewer: Some of the students I interviewed told me that some of the groups worked well and other groups did not work so well. If they were the student who was not "getting it," they felt left out. Other groups would stop and help students who were not getting it. Is there anything you can tell me about the dynamics of your groups?

JW: I think if anyone was behind, I think I felt like I was the farthest behind. But hearing it with everyone else's input, even if I didn't completely understand it, I kind of went with it. I thought if I need to understand that more later on I will go back to it. I didn't feel that was the time to learn it because we only had one hour. And we had 5 or 6 groups to get through. So if I felt like not knowing would be detrimental to my future, then I would ask later. I didn't want to take the time out of that particular session. And I knew I could always go see the tutor or go to the Math Resource Center, or anyone else in the class, for that matter. It's there. It's just a matter of taking the initiative.

Interviewer: Some students said they expected these sessions to show more immediate results – that they would translate to higher grades on exams. What did you think?

JW: Honestly, I was just thrilled to get through the darn class. I had taken it so many times and it had messed up my transcript. I was just happy to get it over with, even though it is not the grade I wanted. It's the grade I expected. That's just the way it is and there is nothing I can do. I mean, I can take it again but I don't want to waste the money or the time sitting through that class again. It was stressful enough for me.

Interviewer: Anything else you would like to share about your experience?

JW: I guess I really liked the fact that we had the option to use a calculator or not use a calculator. Some of the College Algebra classes you have to use a calculator whereas other classes don't allow them. I liked that we had the option. I am not the most proficient at using a calculator but I can figure it out. Plus the instructor would actually give us the formulas and some of them you can program into your calculator so they are right there. You still have to remember what the right times were to use them as well as the right inputs for the particular variables. That was helpful – her giving us the formulas in advance so we didn't have to memorize formulas. Unless you are geared toward math as your future, it's just very difficult.

SC, female, Caucasian, traditional student who was in her first year out of high school

Interviewer: Begins by describing the study and getting signatures on the permission form.

Interviewer: Could you describe your experiences in math classes prior to this class?

SC: Ok. I am one of those people that kind of struggles with math. And so I have to take everything really slow when it comes to math and I have to repeat everything before I get it. And so I took pre-calculus the semester before I came here and I really struggled with it. I think part of it was that it went so quickly and I was never able to really keep up with the class. Before that I had analysis and I did okay with that but it's just because I feel like the teacher was slow and she really helped us when we didn't understand something.

Interviewer: Describe your experiences in this math class.

SC: I really liked how everything flowed in this class. I liked how slow Mr. ______ took everything and I really liked that the tutor reconnected with the group of girls I hung out with during the day. In the class we connected with the tutor because we would go to the tutoring center almost every day to do our homework and just to get it done. It was the relationships I built in that class and it made me really sad to leave the class, which is weird for me because I am usually really happy that math is done.

Interviewer: What things helped you learn?

SC: I had a 7:00 a.m. class that ended at 8:00 and then my math class didn't start until 9:00 so I would sit and wait for my next class right outside the door for just an hour. The tutor was always there so obviously we sat there and chatted for an hour almost every day. So I already started to build a relationship with him because he was in my math class too and so it makes math so much more fun when you are doing it with friends. The tutor was just one of us. Whenever we talked about how old he was we told him you don't seem old; you seem like one of us.

Interviewer: What things made it difficult for you to learn? If so, what were they?

SC: In this class particularly? I think sometimes I am always a positive person so sometimes when other students would get real negative about something and it would just frustrate me. I guess sometimes when I really understood a concept because I had gone to the math lab for help and someone else didn't get it, it was irritating to me that we had to go over it over and over and over again. But besides that, I didn't really have any problems learning it.

Interviewer: Can you talk about some of the things that happened in the extra sessions?

SC: The extra sessions were directed by the tutor. It was kind of like a problem-solving thing where we would have really hard problems that we had to try to solve and we would get a week or two to try to figure it out and we would be in groups, too. So, back to the relationship thing I think with that class what helped was switching groups around and finding who you worked best with and just getting to know more people in the class.

Interviewer: Have you taken classes where groups were a big part of the learning?

SC: I have and I remember not so much math classes, more history and group projects in English.

Interviewer: Can you talk a little bit about those experiences?

SC: I think a lot of it has to do with the number of people in the group because if there are too many people in the group I have noticed there are just one or two people doing all of the work. And there's two or three people just hanging back not doing anything. But if the groups are too small I think a lot of times both people don't get it and they don't get anywhere. I have had a little bit of both. I have been the one who has done most of the work but I have also been the one who didn't know what was going on. Smaller groups I think are the best.

Interviewer: Has this class changed your attitude about math in any way?

SC: Yea, because the class itself just came to me really easily and I don't know if that's because I am just really good at algebra or if it was because Mr. _____ just took things really slow where we all understood. Whenever I started to build relationships with girls in the class that didn't get it, they wouldn't get it as well as I did, I would still go to the math lab with them and get that extra practice and it just made me realize how important it is to do your homework and make sure you understand every detail.

Interviewer: It sounds like when I hear you talk you almost played a mentor role. Is that true?

SC: I think part of that is sort of true because I had taken pre-calculus and I knew a lot more than a lot of the other girls or guys. Or it had been so long since they had taken it. And I had just taken it that semester before so I feel like it came to me easier than it did to some people so I tried to help people out. So yeah, in a way.

Interviewer: Has this math class changed your career plans in any way?

SC: Maybe kind of a little bit. I am not sure if it was this class specifically but after this semester I have just really raised my standards. Before I was thinking about being a special education major or nursing and I was leaning toward special education because I thought it would be easier. But this summer I changed my mind and I went back to nursing. I can't stop myself. I think the grades I got this semester helped that because I realized what I can do.

Interviewer: So if you would have gotten, say, a C in College Algebra, you would have said to yourself, "there is no way I am going into nursing?"

SC: Maybe. Definitely. Definitely.

Phase Two:

Interviewer: Tell me about the relationships you built during the supplemental sessions.

SC: I thought it was different than any other math class because it just made the math class more fun. Usually toward the end of the semester, the students have somewhat of a relationship with the teacher. But I felt like our class (at least the few girls that would go to the tutoring sessions or go to the Math Lab after, those students connected a lot better with the tutor. It was almost like we went to summer camp together and then we had to leave. It wasn't like a class. It was definitely like a friendship and we actually keep in touch now.

Interviewer: Did you think it was unfair that you had to attend additional sessions when other students taking College Algebra did not have to do this extra work?

SC: Sometimes I did, just because it was an extra hour that we didn't get credit for. But I think because I am usually such a positive person, I mean I knew it was something we had to do so I don't really see the point in making a big deal about it. I always made it the best that it was. And the classes really weren't that bad. In the beginning we all complained about it but in the end only a few people complained about the sessions.

Interviewer: What do you remember about any of the topics in the sessions?

SC: I just remember the challenges we had to do were usually pretty hard. They weren't something you could sit down and figure out in a few minutes. They were things you had to really sit down and think about, plan out, and even think about how you were going to get started. I kind of liked it because once I did come to a conclusion, it always felt really good. You felt like you accomplished something.

Interviewer: Would it have been better do the sessions instead of classes rather than in addition to?

SC: Yeah, that definitely would have helped. I think it would have been more enjoyable if people didn't think that it was something they had to do but didn't get credit for. I think if there was a set day during class when they did this kinds of things it would be more beneficial; it would be like a break from class time to do something else. It would be viewed as a more fun way, I guess.

Interviewer: Was there a time when you were taking a test that you felt like you knew something better because of the work you had done in the session?

SC: I don't know if the sessions specifically helped me figure out how to do something. But it definitely helped me understand it better. Math is more of not if you know how to do it it's more about can you do the equation the right way. With the additional classes I felt like it helped me understand more how to do the basic problems because in the sessions we had such hard problems.

Interviewer: I know you said you bonded well with other students in your group. Were you in a situation where someone in the group was not getting it? If so, what did you do?

SC: Yeah, that did happen. I feel like that happened quite a bit but it never took very long for a group to explain. I feel like our group didn't have a problem with stopping and explaining to the person who wasn't getting it. Basically we would just stop what we were doing and help that person keep up because we all know what it feels like to be behind. We hate that feeling.

Interviewer: A person in another group told me she felt like people just said, "never mind. We will just do it." She felt like she was kicked out of the group. I am hearing you say you didn't do that. Is that right?

SC: I tried to for the most part because I hate that feeling when you don't understand.

Interviewer: Were you the leader of your group, making sure that everyone was getting it? Or was there another leader who stopped your group when someone wasn't getting it?

SC: I think I was a little bit. I also think Melanie played a leadership role, too. Aside from the tutors, obviously. Now that you said that, I do recall some people going on and not helping some people but I would usually try to sit with that person and help them get it.

Interviewer: Is that a role you have played in other classes or other subjects? Are you often a mentor?

SC: I guess it just depends on the subject. If I am weak on the subject, then obviously I am not going to be a good leader. I have always kind of been someone who feels bad for the weaker person so I always try to help the weaker person. Especially with things I do get, I definitely play a leadership role, I believe.

Interviewer: I want to ask you some questions about attitude toward math. You indicated this class changed your attitude about what you will do. Did you notice an attitude change in others? Anyone who got worse or got better during these sessions?

SC: One girl was up and down – it depended on whether she got it or not. She had really bad test anxiety and she would really stress out about it if she didn't get it. I feel like for the most part they were pretty positive outcomes but I think a couple of people the results didn't come back like they wanted it to so they were pretty negative. I think it all depends on how well you did in the class – how you did your homework – stuff like that.

Interviewer: What I hear you saying is that people were looking for immediate results. This wasn't something they were thinking this might help me in the next class?

SC: Right. They were thinking I got a D on the last test and that shouldn't happen if I am doing all this extra work.

Appendix G: Tutor Interviews

Interview with Tutor H:

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?

As far as why, I just love being involved in math in any way I can. So I figured this was a new and different way to interact with different teachers, different students, that kind of thing.

As far as what I wanted to accomplish, I think I have an infectious type of enthusiasm for math and I was hoping that would kind of rub off. If I could get that to happen to one person, that would be great – I just love it so much. That's kind of how I started out with but then you really get more involved as stuff goes on. You end up getting more involved in their lives, just because you see them three times a week. And so it even became more like not really a personal thing but you just become more involved with the students. And that was really a cool thing I wasn't expecting. That was just a nice benefit, side-effect, whatever you want to call it.

2. What did you learn by working with the instructor? Will you continue to use some of what you learned?

Yeah, I mean there's always a billion different ways to explain something, and you are taught a certain way, so that sometimes will stick with you. But you hear it presented in a different way and you think, "hey, I never thought about it like that." With my professor, he does a lot with PowerPoint and I am sort of old school where, when I was taking math classes it was just on the White Board, computers weren't really in the classroom and so it was refreshing to see how technology could be used. "Hey look at this." Even just the PowerPoint stuff, a lot of students even commented to me that they liked that a lot because he would present the main bullet points. They weren't writing a bunch of minutia down and so they could get the main concepts. Then he would give examples so I thought that was a neat and interesting way to go about things. I learned something new.

3. What did you learn by working with the students? Will you continue to use some of the things you learned?

The biggest thing is, and I guess we probably know this already, everybody learns differently; everybody learns at different speeds, in different ways, so it really forced me to not just be a dictation machine, where I just repeat back stuff over and over and over again. "You do x, y, and z. Oh, you don't get that? Why not?" Because you are interacting with so many different people – it's not like being in the Math Resource Center where it is one-on-one. When you do a group type of thing where you give your overview and then you see looks of confusion on their faces, and you think what else can I say? The other thing is I tried to balance not giving away the farm as far as the projects go. How can you say something in a different way – not just repeating what you already said. I think that is probably the biggest skill, improvement for myself – finding different ways to say things. Being able to read their expressions – this is obviously not getting through. What questions can I ask to see how well they have learned stuff in the past and how I might correlate that with how I can explain this.

4. What were some of the positive things you observed or heard about the sessions from the students?

I think for the most part they liked interacting with each other – doing group work to tackle a common problem. It helped them reinforce something I had said, "look, if you can do this kind of thing, think of what you can do on the homework or on a test. This should give you the confidence to tackle this, you should be able to tackle the other stuff you have to do." I think there was a bit of a self-confidence thing; "Look, I did this hard problem and the stuff in the homework isn't nearly as hard; if I can get this kind of stuff down then I can get the other stuff down. So there was a confidence.

5. What were some of the negative things you heard about the sessions from the students?

Probably the biggest negative was that the biggest complaint was that the projects don't pertain to anything that they are doing are going to be doing. And I said it's true you may not be doing x,y,or z in a job but the skills of critical thinking, following logical paths and processes, those are going to come up in whatever you do. Try to put aside the fact that this may not be something that interests you personally and try to look at the benefits of what you are getting out of trying to solve a complex problem. It's not just a cookie-cutter thing where I can do 1,2,3,4 and then I am done. You have to ask yourself what happens next. So that was the biggest complaint so I would try to take those negatives and turn them into positives. Not everybody is willing to listen to that. It's an individual thing and they take out of it what they want.

6. Did you see examples of students who succeeded in the class because of the sessions? If so, what were they?

I am not sure if it was specifically the sessions. I definitely think it had an impact but I can't say it was 100% because of the sessions. I am sure there are other factors that go into it. But there was a student in the spring and within the first week or two of school she said to me that she had taken College Algebra before at another school and she said, "I am not good at this, I can't do it, I am going to fail", you know, all those kind of negative things. As the semester went along and as she did more projects and I also did those study groups, a combination of all those things and her working hard at it too, I think she nearly got an A. I know she got a B. That's a success story when you take somebody who says, "Oh my God, I know I am never going to be able to do this" doom and gloom and to nearly get an A. She was happy to get a B. That's what I think.

7. Did you see examples where students were not successful because of the sessions? If so, what were they?

Yeah, there was a guy who this was the second time taking the class and the second time doing the projects. I don't know if it is more of an outlier kind of a situation or a unique example but he was like this the first time through – just not as cranky. I think he passed the class which is all he cared about, but he was so negative that it even started rubbing off on other people. A good thing that came out of that is that other people finally told him to tone it down. You are making us angry over here. That's a positive as far as that goes. He was just doing the work to do the work. You should be doing the work to learn something not just so you can get a grade. I mean that's my personal belief about it.

8. Is there anything else you want to share about your experiences with the sessions?

For me it has been really enjoyable, for the most part. I get al.l geeked up about anything math, pretty much. Anything that is outside the norm of what I am doing – private tutoring, tutoring in the math center – this is a unique type of environment. You get to be in the classroom, meet with the teacher and discuss things; it was just a really cool experience. It also takes you out of your comfort zone a bit. At first, I mean I knew I could do the work, I wasn't worried about that; again it is just something that is new and different. It becomes more of a routine thing. I look forward to doing this as long as I can.

Interview with Tutor I

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?

I am interested in becoming a professor and I thought that being involved with it would give me a chance to work more closely with the professor. To observe class every day would help me learn how to teach the material and observe what type of relationships the professors developed with their students. Another factor was that I had been working here (the Math Resource Center) for a while and I do like the students here a lot and the opportunity to work with some of them more closely over a period of a few months interested me.

2. What did you learn by working with the instructor? Will you continue to use some of what you learned?

I got to do the study twice and one thing I noticed was how two people with very different personality types could approach the material – how they could get through it all – how that could be done. I think there were some teaching things specifically – how to explain things with more clarity, how the functions behave, things like that, and where to draw the line on what is too much emotional investment. The bulk of my experience has been either with very small groups or one-on-one tutoring where I get really involved with the family. When you are starting out with 24 students, it’s a little different environment.

Quite a bit. I saved all the lecture notes I got from both fall and spring and I saved all of the material from the group study projects. And that was intentional. It wasn’t just me not throwing anything away. There were files created because I want to save all of this in case I am teaching College Algebra sometime.

3. What did you learn by working with the students? Will you continue to use some of the things you learned?

I am trying to separate my answer from what I do in the MRC because I think one thing I have learned from the students here is that you don’t have to love math to succeed at it (laughing). But not loving math can really get in the way. I saw a lot of how technology can frustrate a student and get in the way of learning, specifically in College Algebra, someone who had never worked with the TI-83 or TI-84 before. I worked with those students quite a bit and one thing we found in the classroom was that it was helpful to have me in the back of the classroom to work with these students who would say, “how did you get that up there?” I could hop up and get them through that. I think one of the things I learned there was that even things like a calculator, which comes easy to me, doesn’t necessarily come easy to the students. I think also the online homework - seeing how that worked in with everything else and what the students think is a computer being really picky is really teaching them the grammar of math. That stuff matters.

4. What were some of the positive things you observed or heard about the sessions from the students?

One of the positives, especially in the spring, was how quickly students were connecting with other students. “Hey, we are going to be in this 3-person or 4-person group for the next four weeks, we need to look out for each other.” I saw a lot of that. Some of the sessions, especially if there was a bit of a competitive environment, “hey, let’s see if we can come up with something no one else can figure out.” Or, one of our projects was on who could make the most money. That part got them to dig deeper into the material to really learn it to try to win the contest. The good thing about the "make the most money part" was seeing how the math applied.

5. What were some of the negative things you heard about the sessions from the students?

I think some of the students felt that it was unfair that they had to go this extra hour when some of the other students didn't – students from the other College Algebra sections. Especially in the fall section I was in, students signed up for that section because it was the last College Algebra section that was open. So they didn't really seek out all these extra hours of instruction. Given that attendance on these wasn't perfect, it wasn't just the effect of one person deciding not to come. One person deciding not to come to the group session that day affected others. It was a little different from missing a day of lecture for whatever reason. That had consequences beyond themselves. So having that type of group dependency was a bit negative.

6. Did you see examples of students who succeeded in the class because of the sessions? If so, what were they?

In the fall section, the thing that stood out the most for me – it was almost an accident because of the calendar – we started a session on sequences and series before the formulas had been taught. The people who were at that session did great on that chapter. Because suddenly for them that part wasn't about having another set of formulas to memorize. It was how are we going to express these things that we learned how to express in groups the week before. So it wasn't "here's the formula memorize it" it was "oh that's this situation so it requires that."

In the spring, I don't know if the numbers back this up, but I felt that that group did a lot better with polynomials than the other group did and I think a lot of that was because we did this competition of who could come up with a polynomial that other people couldn't guess. From that they learned all the tricks – the more difficult things you might not know to look for. Things like double roots and triple roots.

In the spring session, (I hope I can get through this – it's kind of emotional), in addition to meeting as a group, they also started to get together before midterms and things like that. For a couple of those sessions I showed up to help them out. One of them was when they were all coming here the night before the midterm; there was the night to do the review, the midterm the next day, and the drop deadline was the day after that. That review session happened to be on my birthday. But my family, we have always been we can celebrate our birthdays on the weekends and I told the students I would come. The word got out that I was doing this on the evening of my birthday. And one student pulled me aside beforehand and said, "I was actually going to drop the class this afternoon but I knew that you were coming to the review session on your birthday. So here I am." And she passed the class. And she was also in the first trimester of her first pregnancy.

7. Did you see examples where students were not successful because of the sessions? If so, what were they?

The biggest area of concern was the students who just decided not to come to them and they were graded. In the spring section we had one student who had no trouble getting through the material; he just decided that these group sessions were something he was not going to do. He ended up passing the class fine but he probably would have gotten an A in the class if he'd just decided to come to the group sessions. I think any barrier to success was just, "oh, I have this extra hour of math that I've got to go to." In the fall session, that was more of a problem because the group session was on a different day than lecture. You'd have students who were either not showing up at all or were showing up 10 or 15 minutes late, hoping they could sneak into the group and hoping they would get full credit for the session. That started to get in the way a little bit. Other students would say, "why is this fair? Why should I come on time if other students don't have to?" I can't think of any specifics where the material covered in the group sessions actually made the rest of it worse.

8. Is there anything else you want to share about your experiences with the sessions?

I am curious about how the data plays out because I am skeptical about how much the group sessions themselves raised grades as much as getting everyone to work together and getting to know each other did. I imagine this helped a few people get over the barriers of, "when am I ever going to use this?" because we would talk about those things a lot. But I am curious if it was just forcing students to spend extra time together and work together that was raising scores. I would be interested down the road if we want to compare that extra hour of not just being group sessions but being just a recitation section and seeing what that did.

Appendix H: Instructor interviews

Instructor A and E

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?

    I decided to take part in the study because I like anything that is coming down the pike that will help our students learn math. I felt like this was an opportunity to help students. I hoped there would have been more dramatic success which I guess translates for me into students doing better. I was hoping also that, once we got this going, more of this would have caught on, for students as well as faculty.

2. What did you learn by working with the other instructors? Will you continue to use some of what you learned?

    Yes, I will continue to use what I learned and probably the one big thing that we worked on was electronic discussions boards through ANGEL that had the class talking to each other. I thought that was a great thing that we came upon that I will continue to do. I will do this in some of my classes this coming fall. That's something that I don't think we planned to happen. It just kind of came about. I learned something about improving how to ask questions. Because we worked on that – we hammered out not only questions but the wording of activities – I realized how important that is. When you are working by yourself you don't tend to ask yourself, "Does this really come across the way I want?" I learned that. I think I learned it was okay to not feel that I am in competition with other instructors. I think that can happen when you get together with other colleagues and feel like you have to compete with each other. I did not feel that at all. I think it could have been that way but working with everyone was great. I did not feel competitive. I felt like there was a good cooperation. Other things I learned is that other people are just as concerned as I am about how students are doing as I am. I think together we looked at data and I learned how other people tend to look at data – different ways to consider data. I learned about collaborating with others that it was okay to express my opinion – some people thought my ideas were okay and some people didn't. I don't think anyone owned the supplemental projects.

3. What did you learn by working with the tutor? Will you continue to use some of the things you learned?

The biggest thing I learned from working with the tutor is that students are more open about their comments about things than they are in the classroom. They are more open with the tutor than they are with me. The tutor would share things that I didn't realize. He had an insight into students that I was not able to pick up in class. He would say tell me about students really getting something or really liking something and I thought students were really struggling with it. He was able to let me know how students are really doing – how they feel about the class, how they feel about supplemental projects. How will I use what I learned? I don't know. In the future I would somehow like to use a tutor in the classroom just as a model, but I don't know how that would work.

4. What were some of the positive things you observed or heard about the sessions from the students?

I don't know if I actually heard this but I observed more communication among students in the classroom, because they were together for an hour once a week talking to each other. They didn't say that – I observed it. The class started out being very quiet but by the third week, the class was very verbal. As far as positive things about the actual projects? I did hear one student talking about a test question who said, "We talked about this in our groups. I did the problem right because we did this in our group." I thought that was a real positive thing. I did hear something on the first day in the spring semester. A student on the front row said, "I heard I can get extra help in this class."

5. What were some of the negative things you observed or heard about the sessions from the students?

Some of the challenges – at the beginning I heard, "why do we have to do more time?" I had an interesting challenge because I had a very negative person in my class; I really think that person colored other people's views about the sessions. I don't know that I heard anything specific. I am not sure students were making the connections of what they did in the sessions and what was happening in class. Or what value it was to be doing the projects. The discussion board helped me understand their feelings about the sessions. It was obvious they were trying to make connections. I didn't hear it, but I read it.

6. Did you see examples of students who succeeded because of the sessions? If so, what were they?

I would say they succeeded because of the sessions because they stayed in class longer. I think some of the student would have dropped out. I don't like my drop rate at all but I think I would have had more drop out if not for the sessions. But they at least were talking to each other and I think there was a kind of "let's hang in there together."

7. Did you see examples where students were not successful because of the sessions? If so, what were they?

I don't think so. Not because of the sessions. There were students who were not successful but I don't think it was because of the sessions.

8. Is there anything else you want to share about your experiences with the sessions?

Yes, I think it was a challenge at the very beginning for the instructors involved to get together. It was difficult for us to find times to get together to talk about the projects. I think it seem liked extra work sometimes to get together but after I talked to one of my colleagues, I felt better about what we were doing.

I would like to have had a little more debriefing at the end of the semester to talk about what we learned.

A good thing we did was to wait a week before starting the sessions. I think it is okay to talk about the projects in class but to actually do one of the projects in the first week of class is difficult because there is too much going on in the first week or two of class. That was a good thing we did.

It was okay that I wasn't there and to let the group learn on their own. I don't have to be there. Students can learn from each other. That's a big thing I learned. I wasn't there and they learned anyway.

I think there is a temptation for the tutor to become a teacher, rather than a facilitator. And maybe we should offer more training. We did that a couple of times but maybe we could do it better.

I think working together with another instructor we tend to address problems earlier. We see something come up and we address it earlier. I don't even tend to think about some of those things when I am by myself.

I think students were working outside of class together because they had formed a group. They formed a study group and studied together. Even though I changed group membership, there were still several groups from that class that got together, that I don't think would have gotten together otherwise. One of those people got an A in the class.

I think having COM 319 was a plus – it gave a different environment. Having a different environment was good.

I think the projects improved from one semester to the next. I think the instructors who originally wrote the projects would have approved the improvements. We change from doing something almost every week to having several weeks to work on the same topic. And we were more intentional about the presentations. We were originally going to do some videotaping but I am glad we didn't. We weren't ready for that.

One other thing: I wish we could have dealt more effectively with the problem student I had.

Instructor B

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?

I saw the problems present in the current College Algebra course – the way we are teaching it now. There was an obvious need to improve it. In the past, I have always been willing to try new things; this looked like a promising opportunity to see if we could improve student success in College Algebra.

The big thing was to improve success. In particular, for me, as we put together the questions for the groups, I wanted to see if we could create other things besides more skills repetition. I wanted to see if those things would have an effect.

2. What did you learn by working with the other instructors? Will you continue to use some of what you learned?

We hit ideas back and forth. I learned so much from the process but it is hard for me to say "this came from the other instructor." It was more of a sharing and a synergy of ideas that come from two people working together. As you get ideas, you incorporate them but you never realize where those ideas came from. I think a lot of what happened in the process would not have happened without the other instructor's input. In that sense, it was a vital part of what I learned but I would be hard-pressed to say, "This is how I now do it differently."

I am hopeful that I will continue to use what I learned. I guess if there was one thing I really did learn it was how individual students were affected by working in groups – how some of them grew and how some of them reacted negatively. That was no surprise. You usually get a variety of responses from anything you do.

3. What did you learn by working with the tutor? Will you continue to use some of the things you learned?

The biggest thing I learned from working with the tutor is that the tutor was very free of the negative connotations that come with being an instructor. The students were quite open with him in ways that they were not with me. I guess there is less fear of being seen negatively by the tutor. So he had a lot more ability to relate to students, I think, than I did.

Can I put that into practice? I haven't figured out how to take advantage of it yet, because I can't exactly remove my role as instructor. He gained something there. I'm actually kind of envious.

4. What were some of the positive things you observed or heard about the sessions from the students?

Some of them did in fact say that this made a difference in how they viewed the course, in their confidence level, and in their willingness to stay in the course and not drop. I heard all of those things, in fact, some of the questions I asked at the end on my survey, also stated those things.

5. What were some of the negative things you observed or heard about the sessions from the students?

Group dynamics. The individuals in the groups did not always work equally well together. There was one situation that got to the point where the tutor and I had to deal with a particular student. Eventually, we decided the tutor would tell him if he wasn't going to contribute to his group, he would work in a group of one. It solved the problem for the others in his group.

There was some original griping about the extra hour. Most of them eventually came to the point that they believed that the group sessions were helpful. So that was a transient negative.

6. Did you see examples of students who succeeded because of the sessions? If so, what were they?

I think so because some of them chose not to withdraw because of the group support that they received. And knowing that they had their own special tutor made a difference. So in the end, they passed – maybe only with a C, but they passed. They would have given up sooner. I think that would be my basic comment in that area. I cannot say that in a particular group any of them did a whole lot more wonderfully than they would have. I suppose some of them might have.

7. Did you see examples where students were not successful because of the sessions? If so, what were they?

I don't know that I would say that any of them were not successful because of the sessions but some of them hurt their grade because they refused to participate in the sessions and they therefore did not earn the points. But in the end, I believe they generally passed. I would have to look at the grade book.

8. Is there anything else you want to share about your experiences with the sessions?

I think having seen a number of the students do better, in particular, it was very noticeable when we got to the end of the course when we were dealing with sequences and series. The groups who had the sessions were much more willing to investigate patterns and try things whereas the control group was still interested in looking for formulas. And that was a terrific result. At some point during that semester, the groups had gotten over their fear of math – the experimental groups were initially very weak. I think it got to the point where they were willing to try things without so much fear. What I would really like to figure out is how to get that kind of response in a classroom that doesn't have the sessions.

Instructor D:

1. Why did you decide to take part in this study? What were some of the things you hoped would happen?

One of the reasons I decided to do this was because these are the types of things that I would like to do in my classroom if I had time. The College Algebra curriculum is so full that it is hard to get everything done that we want to get done, and so doing some of those connections and some of those fun things, we don’t really get to do that very often. Our fun consists of getting them into groups to talk about things that I am explaining, as opposed to them discovering things for themselves.

What I really hoped was 1) that the students would form more of a community – get to know each other well. The other thing was that they would be able to see how this relates outside of a math classroom. The thing we did with finding loans and investments, I think sometimes they don’t see those connections between what they are doing in math and how that extends outside the classroom. That’s really what I hoped.

2. What did you learn by working with the other instructors? Will you continue to use some of what you learned?

I really like working with other instructors but one of the things that I learned was the discovery phase. I enjoy pulling projects and getting ideas from other instructors but it is really difficult for me to come up with those discovery ideas – how do we get students to come up with those connections? Talking with other instructors, bouncing ideas off of them, stealing ideas from them (I don’t like that word "stealing" because they wouldn't consider it stealing), how do we get students to discover some of these things?

Most of the projects that we did before I am going to do in my 5-day-a-week College Algebra class this fall. All of those little things I pick up are all going to go into what I do now.

3. What did you learn by working with the tutor? Will you continue to use some of the things you learned?

Honestly, I think one of the things I learned from working with the tutor, and it is not something he said or did, I see the instructor in the front, over here [gesturing with one hand]. And I see the students here [gesturing with the other hand]. And the longer I do this, the farther away from the students I get. And I am not sure why that is. I didn't start out that way. I think working with the tutor really helped me remember what that is like – to work with the students as opposed to – I don't want to say working against them, because I am not working against them – but it's working with them as opposed to telling them stuff. And that has always been my goal. I don't want to be that person standing in front of the room saying blah, blah, blah. I want to be beside them, helping them. He really helped me remember that kind of stuff.

4. What were some of the positive things you observed or heard about the sessions from the students?

The main positive thing is getting to know other students, the community that is formed working on these projects. The different type of setup where they are not sitting in a desk, facing the front, listening to the instructor; but looking at each other, talking to each other, and getting to know each other. Some of the more positive comments in our discussion posting were “I‘ve never gotten to know anyone in my math classes before.” Or, “I didn’t realize how having someone to talk about it with, what a difference that would make.” So the community was the big positive thing. There were a few comments about “I didn’t realize that College Algebra applied to this particular project that we are working on. I didn’t realize you needed College Algebra to do the one where you needed to make money.” Those were some positive things.

5. What were some of the negative things you observed or heard about the sessions from the students?

The biggest negative that I heard was about the extra hour that I have to come. To me, I can kind of understand that, especially on a Tuesday, Thursday schedule because the extra hour was hard for them. And there were some students who didn’t think some of the projects were anything except busy-work. I saw a lot of students just not come. On any given day, if I had 15 students in the class, we were lucky to get 10. And it wasn’t always the same 10 that were not coming. The Albuquerque problem to them, there were some really good things that came from that, because I know there were 3 or 4 students who continued to work on that on their own, because they were intrigued by that and they wanted to get it. On the other end of that, the majority, probably 80% of the students said, “that was just way too much, that was just busy-work. I didn’t see what relevance that had to my life.”

6. Did you see examples of students who succeeded because of the sessions? If so, what were they?

Yes. There were these two women who succeeded I think because of the sessions because it kept them connected to the class. I'm not sure if it was the projects. The projects we did where they were defining functions really helped those two women in particular understand what we meant by the word "function." Getting that at the beginning of the class helped them get through the class. I think having the tutor, because he was available outside of the sessions for help, that helped in the success arena, because he held 2 or 3 review sessions before every exam and he always had the same 6 or 8 people show up and that really, really helped. That was outside the scope of the projects. But I think it was because of the projects he got to know them and they got to know him and that helped I think.

7. Did you see examples where students were not successful because of the sessions? If so, what were they?

I did have one student, because this was 10% of their grade, he could have easily aced the class, but he didn't bother to go to the supplemental sessions, and he ended up with a high C for a final grade. And I don't know why he didn't come. Just that extra hour. He's the one that really stands out because I have had in my class before and he is so bright that I don't think the grade he received reflects his knowledge of the material. I think he penalized himself because he didn't want to come to the extra hour of work. And I don't know if that is because he had a conflict in his schedule. I know he went the first day. From what I know of him he is a very introverted person so I think having to get out there was difficult for him. And I understand that. That's how I was when I was in college, too. I think he is mainly the one.

8. Is there anything else you want to share about your experiences with the sessions?

My personal experiences with the sessions – I think they were very difficult for me. Part of the reason they were very difficult for me was because I want to control every aspect of what goes on. So it was very difficult to turn them over to the tutor. Some of that I think, and I have been thinking about this all summer, some of that I think is arrogance on my part. I don't really see myself as an arrogant person, but I think in my mind there is a difference between an instructor and a tutor. While the tutors are awesome and he did a great job, in my mind, should that have been an instructor? And not even necessarily me, but someone who has had that experience in that role versus a tutoring role. I worked with two instructors in our Learning Strategies program and to me, that was much easier than working with the tutor. I just have to think that is an arrogance thing on my part. I don't know. I see the good in having the tutor do it. I think it is an excellent idea to have those students move away from the instructor to do these things so they don't feel intimidated. Good and bad.

I loved the projects. I could never have thought of all these cool projects. I love the projects. I love the idea of them, I love having students think about those kinds of things, so the 5-day-a-week class is going to allow me to use them and it may even be the case that if I teach the class 3-days-a-week I may try to incorporate some of that as well. They are just that good.

Appendix I: Table of Days

Table of Days

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	1	32	60	91	121	152	182	213	244	274	305	335	1
2	2	33	61	92	122	153	183	214	245	275	306	336	2
3	3	34	62	93	123	154	184	215	246	276	307	337	3
4	4	35	63	94	124	155	185	216	247	277	308	338	4
5	5	36	64	95	125	156	186	217	248	278	309	339	5
6	6	37	65	96	126	157	187	218	249	279	310	340	6
7	7	38	66	97	127	158	188	219	250	280	311	341	7
8	8	39	67	98	128	159	189	220	251	281	312	342	8
9	9	40	68	99	129	160	190	221	252	282	313	343	9
10	10	41	69	100	130	161	191	222	253	283	314	344	10
11	11	42	70	101	131	162	192	223	254	284	315	345	11
12	12	43	71	102	132	163	193	224	255	285	316	346	12
13	13	44	72	103	133	164	194	225	256	286	317	347	13
14	14	45	73	104	134	165	195	226	257	287	318	348	14
15	15	46	74	105	135	166	196	227	258	288	319	349	15
16	16	47	75	106	136	167	197	228	259	289	320	350	16
17	17	48	76	107	137	168	198	229	260	290	321	351	17
18	18	49	77	108	138	169	199	230	261	291	322	352	18
19	19	50	78	109	139	170	200	231	262	292	323	353	19
20	20	51	79	110	140	171	201	232	263	293	324	354	20
21	21	52	80	111	141	172	202	233	264	294	325	355	21
22	22	53	81	112	142	173	203	234	265	295	326	356	22
23	23	54	82	113	143	174	204	235	266	296	327	357	23
24	24	55	83	114	144	175	205	236	267	297	328	358	24
25	25	56	84	115	145	176	206	237	268	298	329	359	25
26	26	57	85	116	146	177	207	238	269	299	330	360	26
27	27	58	86	117	147	178	208	239	270	300	331	361	27
28	28	59	87	118	148	179	209	240	271	301	332	362	28
29	29		88	119	149	180	210	241	272	302	333	363	29
30	30		89	120	150	181	211	242	273	303	334	364	30
31	31		90		151		212	243		304		365	31

Appendix J: Core Question Outline

College Algebra Course Objectives:

Upon successful completion of this course the student should be able to:

1. Analyze functions and their graphs.
2. Sketch the graphs of functions, including constant, linear, absolute value, square root, polynomial, rational, exponential and logarithmic.
3. Solve polynomial, exponential and logarithmic equations.
4. Solve systems of linear equations and systems of linear inequalities.
5. Create mathematical models to solve application problems.
6. Analyze numeric and algebraic patterns; generate numeric and algebraic patterns.

Core Questions and Relationship to Course Objectives

1. Given a set of graphs, identify which graphs are functions (Objective 1)
2. Given a graph of a function, perform an indicated operation on the graph, such as $g(x) = f(x-1) + 3$ (Objective 2)
3. Given the equation of a function, identify the inverse of that function (Objective 1)
4. Find all real and complex zeros of a third degree polynomial function (Objective 3)
5. Find all asymptotes, intercepts, and domain and sketch the graph of a rational function (Objective 2)
6. Solve for x in a logarithmic equation (Objective 3)
7. Given the exponential growth rate, find the time it takes for a city to grow to a certain population size (Objective 3, Objective 5)
8. Solve a dependent system of equations of with three unknowns (Objective 4)
9. Find the sum of an arithmetic sequence given properties (Objective 6)
10. Expand a term using the Binomial Theorem (Objective 6)

Appendix K: Permission to modify and use Attitudinal Survey

Jeff:

I checked with my grad student Rachel Manspeaker (who wrote the survey and so owns the copyright) and she said it was fine for you to use it. I've attached a copy of the questions. We do want to warn you that it is still in development and we don't have data yet on exactly how to interpret the results or how well the survey works to match actual behaviors (we'll know more in October). I'll probably also contact our IRB to see what rules would be on our using your data in research.

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