THE IMPACT OF SUPPLEMENTAL INSTRUCTION ON THE ACHIEVEMENT OF COLLEGE ALGEBRA STUDENTS AT A SOUTHEASTERN TECHNICAL COLLEGE

by

ALYSEN HEIL

(Under the Direction of John Schell)

ABSTRACT

Increasingly, students are enrolling in college who are less prepared for college academics, and require remedial courses. The Supplemental Instruction (SI) program is one remedial program that may aid in student success in college level courses. Supplemental Instruction is an academic assistance program, which employs instructor specific peer tutoring.

An experimental study, as designed at a 2-year technical college in Georgia, was used to examine the usefulness of SI in supporting student achievement in college algebra. Supplemental Instruction was conducted for a randomly assigned group of students for the first 5 weeks of a 10-week quarter. Upon completion, students completed a midterm achievement assessment between those who participated in SI and those who did not. The results were not statistically significant, meaning that statistically there was no difference between those students who participated in Supplemental Instruction and those who did not participate.
IMPACT OF SUPPLEMENTAL INSTRUCTION ON ACHIEVEMENT OF TECHNICAL COLLEGE STUDENTS IN COLLEGE ALGEBRA

by

ALYSEN HEIL

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M.S. The University of Central Florida, 1999

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by

ALYSEN HEIL

Major Professor: John Schell
Committee: Jay Rojewski
           Elaine Adams

Electronic Version Approved:
Maureen Grasso
Dean of the Graduate School
The University of Georgia
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DEDICATION

I dedicate this project to my family, especially…

to the loving memory of my grandmother, Wilhelmine Heil;

for the never-ending support of my parents, Donna and Werner Heil. They have always been there to encourage me to reach for the stars as I reach for my goals.

*I can do all things through Christ who strengthens me. Philippians 4:13*
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I would also like to thank my fellow classmates from COHORT III. We created a support system to keep each other going through the tough times. I have found a number friends who will be a friend of mine for life.
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CHAPTER 1
INTRODUCTION

Almost all high school seniors believe they are going to college regardless of their grades were in high school (Rosenbaum, 2004). With increased open admission at many colleges, the students’ assumptions might be correct. This might lead to many college freshmen being underprepared for the rigor of higher education. A common remedy is enrollment in remedial course work (Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999). Remedial course offerings have become extremely common for students entering college at an alarming rate. In the fall of 2000, 75% of entering freshman in both 2-year and 4-year colleges needed at least one remedial course in reading, mathematics, or writing. Out of those needing remedial courses, the students requiring mathematics had a proportion of 71% (Parsad & Lewis, 2003). The high percentage might indicate the need for high quality supplemental instruction in mathematics. In research, Hagedorn et al. found an issue with the quality of teaching in remedial coursework at the college level. One of the many findings was less experienced instructors were placed in remedial classrooms; whereas, more experienced instructors were placed in nonremedial classrooms. This can be a problem for students needing the expertise of the more experienced instructor. Another issue found with remedial students was the lack of proper study habits (Hagedorn et al.). To combat this problem at the high school level, students should receive outside classroom assignments such as homework. A common complaint heard from educators in high schools and in higher education was:
It is the whole issue of whether or not our high schools are reaching students. The colleges are saying we are spending a large amount of money doing work that should be done in high school; and high schools are saying higher education doesn’t give us the teachers we need. I listen to that every day. That’s clearly the battle we fight (Ruppert, 1996, pp. 14-15).

This sentiment was restated by Richard Ferguson, the CEO of American College Test (ACT) in the 2005 report about the high school seniors in the class of 2004. He stated, “Both males and females and in all racial/ethnic groups – aren’t ready for college” (ACT, 2005, p. iv). According to researchers of the ACT study, only 40% of the 1.2 million students tested during the 2003-2004 school year were ready for the first course in college algebra. The authors of the study went a step further and stated the percentages of the high school graduates who met the college algebra benchmark by race and ethnicity. The only minority group that had the most college ready students is Asian Americans with 57%. Whites were a close second with 46%. Hispanic American had only 24% ready, and Native Americans had only 23%. The lowest group was African Americans with 11%, but none of the groups tested were 100% ready for college (ACT).

Not all students entering college are directly out of high school. An increase number of students who are older are enrolling. In 2005, the officials at the National Center for Education Statistics (NCES) reported the comparison between traditional and nontraditional students at the college level. In 1989, there were 7.7 million students between the ages of 18 and 24, and only 2.3 million students who were 35 years of age or older. By 2002, the difference was 9.9 million for the 18 to 24 year olds and 3.1 million for those 35 years and older (National Center for Education Statistics). Although a gap exists between the two groups, the nontraditional student should not be overlooked. As students wait to attend college, older students might need a
remedial math course to refresh skills. Horn, Castaldi, and Sikora (2006) stated that if students wait to attend college, then they typically do not take higher level math in high school. This could leave the student less prepared for the rigors of college level math namely college algebra.

With the increasing unprepared population of students filtering into college, many students may need a bridge from developmental coursework to college-level coursework. Currently, developmental education is used to prepare students for college-level work. However, is it enough? Students cannot receive the necessary remedial work in 6 months to compensate for what they should have learned in 6 years of secondary school. A study by Seybert and Soltz (1992) on the effectiveness of developmental coursework indicated that the GPAs of remedial students dropped significantly during the semester directly after the completion of developmental coursework, but then gradually increased. Is there a program that can help students make the transition from developmental courses to college-level coursework?

Supplemental Instruction is just such a program to bridge the gap from remedial to college-level coursework. Supplemental Instruction (SI) is a student academic assistance program that increases academic performance and retention through the use of collaborative learning strategies (Arendale, 1994). The SI program focuses on both the process of learning, as well as the content of the course connected to the program. Learning and study strategies, such as note-taking, organization, and test preparation are integrated into the content of the SI session (Martin & Arendale, 1992). The SI program allows students to learn more than just content in a particular course. It increases student success in ensuing courses (Arendale).

Statement of the Problem

Each year, many students enter college academically unprepared and need remedial or developmental coursework. Approximately one third of entering postsecondary students require
remedial or developmental work before entering college level courses (Bettinger & Long 2006). College teachers reported that students “have gone through high school math classes without gaining a real understanding of the subject matter. We’ve found that they’ve failed in high school, but somehow there’s a C on their report card” (Ponessa, 1996, p. 31). Once students enter college-level math courses, such as college algebra, they find the material extremely difficult and do not complete the course by either failing or withdrawing completely from the course. Thus, students need a program not just to become prepared for a course but also to complete the course.

According the officials at the University System of Georgia Board of Regents Office of Strategic Research and Analysis in a report which was completed in 2000, students who achieved a course grade of a C or better were 46.3% for students attending the course without remedial coursework and 41.1% for students needing remedial coursework (as cited in Burk, 2005). In both cases, the number of students achieving a course grade of C or better is unacceptably low. To increase achievement in college algebra, a program like Supplemental Instruction (Hagedorn et al., 1999) may prove helpful as college students prepare for, take, and complete math courses.

Supplemental Instruction is as an academic assistance program that utilizes peer-assisted study sessions (Arendale, 1994). SI sessions are regularly scheduled informal, review sessions in which students compare notes, discuss course materials, develop organizational tools, and predict exam items (Arendale). In the sessions, students learn how to integrate course content and study skills while working together in a group setting. Because of this study, the researcher plans to expand the SI program to other areas of the technical college used in this study.

The officials at the International Center for Supplemental Instruction at the University of Missouri-Kansas City conducted a voluntary, national study from 1998 to 2003 on the use of SI
in regards to 4-year and 2-year colleges in regards to achievement (Center for Academic Development, 2003). The study showed that students participating in SI programs had higher course achievement than those who did not participate in the program. However, mathematics students had lower achievement levels than other subjects in the study. This is partly because SI is more difficult in areas where prerequisite skills are important (Martin, Arendale, & Blanc, 1996). With mathematics, especially college algebra, skills are like building blocks. Students are expected to have a basic set of skills, or knowledge of algebra, when they begin college algebra. Skills should be accumulated from high school and/or learning support classes taken at the college level.

Purpose Statement

The purpose of this study was to assess the effectiveness of supplemental instruction (SI) on the achievement of college algebra students at a technical college. According to the officials at the Technical College System of Georgia (2008), college algebra is a course that includes the topics of fundamental algebraic concepts, equations and inequalities, functions and graphs, linear and quadratic functions, polynomial and rational functions, and exponential and logarithmic functions.

To ascertain the effectiveness of SI as an intervention, the following questions were addressed:

1. What are the achievement scores of college algebra students who participated in or did not participate in supplemental instruction?
2. Was there a difference in achievement between those who participated in supplemental instruction as oppose to those who did not participate?
Theoretical Framework

The basis behind the SI program is the use of collaborative learning strategies. Collaboration is distinguished from cooperation in that cooperative work "is accomplished by the division of labor among participants, as an activity where each person is responsible for a portion of the problem solving", whereas collaboration involves the "mutual engagement of participants in a coordinated effort to solve the problem together" (Roschelle, 1995, p. 72). During the SI sessions, the participants worked by collaborating on ideas from the topics discussed in classes. Through working together, students gained a deeper understanding of their course material.

According to the research from Caberea et al. (2002), collaborative learning is effective both inside and outside the classroom. Collaborative learning aids “the ability and motivation of students towards their personal development, understanding of science and technology, appreciation for art, analytical skills, and openness to diversity” (Caberea et al., p. 29). Also found was that “collaborative learning practices had the highest effect, well beyond those attributable to pre-college academic ability, gender, ethnicity, parental education, and academic effort” (Cabrea et al., p. 29). In addition, collaborative learning enables students to develop a support community of peers (Tinto & Goodsell-Love, 1993), such as during the SI sessions.

Collaborative learning leads to social learning theory, or to how individuals learn best in social situations. The concept of cooperative learning is a group of students working together to learn the material presented to them in the classroom, which promotes a community of learning. A social perspective on learning, stated by Wenger (1998), is that learning is fundamentally social. As students work together through the difficult material, they create a support system.
The support system allows students to gain an understanding by relying on each other for the solution. This in turns creates a community of learning.

The independent learning cycle is how students who were not part of the SI sessions would synthesize information. The cycle follows the concept of andragogy. The students who participated in this study were deemed adults because they were over the age of 18. In addition, the students may have other life issues in addition to being a student. According to Knowles (1984), andragogy, is based on a design of learning, which includes the following assumptions: (a) Adults need to know why they need to learn something; (b) adults need to learn experientially; (c) adults approach learning as problem-solving; and (d) adults learn best when the topic is of immediate value (Green, 1998; Knowles, 1984). The concept of andragogy applies to the learning cycle after students have attended class and have begun the SI sessions. All students in the course have the same ultimate goal of completing the course.

Significance of the Study

An alarming number of students are entering college unprepared. The problem is greater at the technical college level. Many classes consist of students ranging from still in high school to those who have not been in a classroom for 20 years or longer (Illich, Hagen, & McCallister, 2004). To begin a college career, many students begin in the learning support classroom for reading, English, and mathematics. Do learning support classes provide enough academic support for students to gain the knowledge needed to be successful in college-level classes? This question is not easy to answer, as students are condensing many years of secondary coursework into only months of learning support coursework.

As students begin to make the transition from learning support to college-level courses, an extra level of help is needed. The use of a program, such as supplemental instruction, might
bridge the gap from learning support to college-level coursework or to beginning the college experience after high school. Supplemental instruction is not another tutoring program but a program that increases confidence in learning. One of the goals of SI is to produce independent learners. It is time to break the “dependency cycle” of learned behavior that allows students to remain dependent on the authority figure for their learning (Center for Academic Development, 2004).

Figure 1. The independent learner cycle.

As shown in Figure 1, a new cycle emerges from Supplemental Instruction. It is a cycle where students take charge of their learning through the SI Model. The cycle starts with the
instructor presenting new information. The students begin to process the information but needs help to assimilate and relate the information to existing information. The SI leader steps in to challenge students with discussions about the new information. The discussions could range from talking among students, to a student becoming the creator of new ideas. As the SI session progresses, the students become confident of the new information assimilate information, and then apply the information to previous information. The more familiar the students become with the new information the easier it becomes for students to articulate the information as part of their knowledge.
CHAPTER 2
LITERATURE REVIEW

The review of the relevant literature begins with a discussion of instructional methods used in Supplemental Instruction (SI) programs. The SI sessions can create an environment, which is safe for students to interact, discuss, and process course material. In essence, the SI sessions attempt to create a learning community that is specific to a given course. To begin the discussion of learning communities, the author (a) first needs to review the history of SI, (b) further define supplemental instruction, and (c) state the implications of SI to college success in the first section of this chapter. The second section is a review of the theoretical framework of learning by reviewing social constructivism and social learning theory. The third section is a review of previous research conducted on SI. The final section is a review of the effectiveness of the SI program located in 4-year schools.

Instructional Methods of Supplemental Instruction

Supplemental Instruction (SI) is a student academic assistance program that increases both academic achievement and retention rates. SI traditionally is implemented in courses that have a noncompletion rate of 30% or more (Arendale, 1994). To improve this rate, users of the SI program provide regularly scheduled, out-of-class, peer-facilitated sessions, which provide students an opportunity to discuss and understand course material. To address the retention issue, SI has four conditions identified by Tinto (as cited in Martin et al., 1992; Spann, 1990; Tinto, 1987). Many students (a) feel socially isolated on campus, (b) have difficulty in adjusting to the new environment, (c) are not able to link the knowledge received from class lectures to what they already understand, and (d) experience difficulty in the college environment (p. 19).
History of Supplemental Instruction

Supplemental Instruction (SI) was developed by Deanna Martin in 1973 at the University of Missouri at Kansas City [UMKC] (Hurley, Jacobs, & Gilbert, 2006). Prior to the inception of SI, the University of Kansas City was a private institution in 1963 (Widmar, 1994). At that time, the university was in the process of changing to a public institution called the University of Missouri-Kansas City (UMKC). With this change in college status, the student population started to become diverse both culturally and academically. The university went from allowing only the top 20% of all high-school graduating classes to having an open enrollment policy. This was initially hard on the faculty who made the transition to UMKC because the students were not academically prepared for the rigors of academic study. Thus, the student attrition rate rose from 25% to 45% among entering freshman (Widmar). This sparked the need for committee meetings to decide what to do to decrease the attrition rate. It was not until 1972 that the process began. A call from the Associate Provost for Health Sciences to the Vice Chancellor regarding a grant for $7,000 from a local foundation provided the opportunity to deal with the retention issue (Widmar). The Vice Chancellor enlisted the help of graduate student, Deanna Martin, to initialize the work on the retention issue. She began her research by taking a survey of the Learning Support Directors. From the survey, she found that the directors described the regularly scheduled and remedial classes as “add-on” courses; the directors could not demonstrate that students transferred skills from the remedial courses to the credited courses (Widmar). She also reported that students did not ask for help in a timely fashion and in some cases almost too late to be of service to students. After reviewing the findings, Martin began a pilot study of supplemental instruction programs. The retention committee had a few concerns, such as being cost effective, being measurable through reliable evaluations, and being acceptable to faculty
The faculty wanted a program that had a nonremedial image, required no extra work on their part, and promoted independent learning.

In 1981, after 9 years of refinement, the SI program won certification by the U.S. Department of Education as an *Exemplary Educational Program* (Widmar, 1994). With this award, SI became eligible for funds from the National Diffusion Network, which was used to help other universities, and colleges begin SI programs.

**The Definition of Supplemental Instruction**

Supplemental Instruction (SI) is defined as is an academic assistance program that utilizes peer-assisted study sessions (Arendale, 1997). The SI sessions are scheduled regularly and are set in informal settings in which students compare notes, discuss course materials, develop organizational tools, and predict exam items. Students learn how to integrate course content and study skills while working together in a group setting. The SI program targets traditionally difficult courses, which are defined as courses, which have a 30% or higher noncompletion rates, which means that students receive a D, F, or withdrew from the course. By targeting difficult or high-risk courses instead of high-risk students, the standard remediation stigma is taken away. Historically, difficult or high-risk courses typically share the following characteristics:

Large amounts of weekly readings from both difficult textbooks and secondary library reference works, infrequent examinations that focus on higher cognition levels of Bloom’s taxonomy, voluntary and unrecorded class attendance, and large classes in which each student has little opportunity for interaction with the professor or the other students. (Arendale, 1994, 15).
**Assistance with SI**

The SI program begins the first week of the term. Due to this proactive approach, students can receive assistance prior to the first examination. This is especially necessary for students in a system in which the length of the term is only 10 weeks. The SI program is a voluntary program for students of varying abilities with no effort to segregate students according to academic ability once in the program. This stigma typically attaches to developmental students. For example, a chemistry instructor complained that his students could not simplify a complex fraction. This situation is one area where SI can help the students to review information from a previous course.

**SI Model**

The SI model involves four key persons: (a) the SI coordinator, (b) faculty members of difficulty courses, (c) SI leaders, and (d) the students. The SI coordinator is a professional staff person responsible for implementing the SI program and supervising the SI leader. The coordinator also attends 3-day workshops covering areas of implementing and management, training, supervision, evaluation, and study strategies (Hurley et al., 2006). The SI coordinator is also required to maintain reports of the program. The SI coordinator also relies on the faculty to participate and screen possible SI leaders. The faculty member should meet with the SI leader once a week to discuss the session held, receive information on how the students are grasping the difficult material, or provide materials for the weekly sessions. The focus of the faculty member is to find an SI leader for the difficult course(s) and to give support to the SI leader.

The third key person is the SI leader. The SI leader is a student who has successfully completed the course targeted for the SI program. Ideally, the SI leader would have taken the targeted course from the same instructor he or she are now providing SI assistance. Once the SI
leader is named, he or she must be trained in proactive learning and study strategies and operate as a model student. Some of the study strategies are not taking, questioning techniques, vocabulary acquisition, test preparation, and review of content material (Hurley et al., 2006). “If the students only learn content material and not the underlying study strategies, they will have a high probability of experiencing academic difficulty in succeeding courses” (Arendale, 1994, p. 3). A definitive problem facing the students who move from a developmental course to college-level course work would exist. Thus, the SI leader enhances the learning process by sharing his or her learning strategies with the students during the SI sessions.

Prior to the first SI session, the SI leader must be prepared to facilitate the SI session. To prepare, the SI leader(s) participate in preterm training workshops that emphasize the following: (a) Theoretical basis of learning, (b) teaching methods and forms of learning assistance and that are useful in helping students assimilate the course content, (c) study strategies to integrate course material review into SI sessions, (d) possible problems that might be encountered during SI review session, and (e) actual practice sessions using the SI learning strategies with prerecorded lectures of professors (Martin et al., 1992). The preterm workshop is only the beginning of the SI leaders’ preparation. The SI leader continues training through regular meetings with the SI coordinator. With the training sessions, the SI leader learns to become a facilitator of the knowledge the student learned from the classroom instead of a re-lecturer. The SI leader “facilitates a process of collaborative learning, an important strategy since it helps students to empower themselves rather than remain dependent as they might in traditional tutoring” (Martin et al., p. 7).

The fourth group of key people to the SI program is the students. In order for the program to be effective, the SI program must be proactive and begin the first week of the term. Before a
time or place is set, the SI leader must conduct a survey to find the best days and times for all the students involved. It is crucial for students to take part in the program since it is for their benefit, since the participants of SI are typically in traditionally difficult courses instead of at-risk students. Thus, the academic backgrounds of the students may vary widely. Since the program is voluntary, national research shows that approximately 30 percent of students enrolled in SI courses actually participate in the program (Martin et al., 1992).

The Impact of Supplemental Instruction

The impact of SI measures positive differences in student performance and retention rates. The positive differences are accounted for by a number of features the SI models which, influence higher levels of academic performance. From previous research, the following factors have been stated by SI staff, participating faculty, and students: (a) the service is proactive rather than reactive, (b) the service is attached directly to specific courses, (c) to facilitate SI, SI leaders attend all class sessions, (d) SI is not a remedial program, and (e) SI sessions are designed to promote a high degree of student interaction and mutual support (Hurley et al., 2006). The five factors give students an opportunity to complete difficult course work. The first two factors instill a proactive approach to assisting students rather than after a student have made a D or F on a major examination. Moreover, the SI leader is fully aware of the material and the techniques the participating faculty uses in the classroom. This is extremely useful in such courses as mathematics or in the sciences. The SI leader becomes an outlet for students to voice their concerns about course difficulties. The concerns turn into assistance in understanding the content of the course. With assistance from the SI leader, the students learn the material and thus complete the course instead of dropping out and become another statistic for not completing the course.
National Data Analysis of SI

The International Center for Supplemental Instruction (1997) at University of Missouri-Kansas City (UMKC) collects data on a voluntary basis from institutions around the nation currently operating SI programs. The data collected the current report was from winter 1998 through summer 2003 semesters. The information resulted from 53 institutions, 745 courses with a total enrollment of 61,868 students (as cited in Doty, 2003). Students in the SI program are more successful than those who did not participate in the program (see Figures 2 through 4).

The data presented in Figure 2 indicates the percentage of total course enrollment that received a grade of D, F, or withdrawal (W) as a final course grade. The rate for the SI participants is on average 15% less than the rate for non-SI participants possibly indicating that SI participation helps contribute to a lower rate of non-completion. The highest rate in noncompletion rates was located at 2-year public institutions of higher education with 28.78% while the lowest rate was in 4-year private institutions with 5.63% (Doty, 2003). It would make sense that students at a 2-year college, such as a technical college, would benefit from the SI program.
Figure 2. Percentage of total course enrollment receiving a D, F, or W.


Figure 2 indicates a sample size of 61,868 students, 53 institutions, and 745 classes. Of the total enrollment, 3,866 SI participants received a D, F, or W compared to the 12,910 non-SI participants (Doty, 2003, p. 3).

The data presented in Figure 3 indicates the mean grades of total course enrollment separated by institution type. The grades are on average 0.46 grade points higher for SI participants than for Non-SI participants indicating that SI contributes to higher grades for those that participate in the program.

The data presented in Figure 4 indicates the mean grades of total course enrollment and is a comparison of all colleges to the specific academic discipline of mathematics. As shown, the grades on average are 0.44 grade points higher for SI participants than for Non-SI participants, possibly indicating that SI helps contribute to higher grades for those that participate in the program. For mathematics courses the current national SI data, there was a difference of 0.36 in the mean grade between those who took advantage of the SI program and those who did not. The math courses used in this study included calculus, statistics, all levels of algebra, and remedial math.
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<th>Non-SI Participants</th>
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</tr>
<tr>
<td>Math</td>
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**Figure 4**: Mean final course grades of SI and non-SI participants for mathematics. From “Supplemental Instruction: National Data Summary 1998-2003” by C. Doty, (2003). Kansas City: University of Missouri.

Though the difference in the mathematics mean grade is insignificant, any improvements can create a big change in a student’s direction to complete a course or program of study. The concept of improving completion rates is where the author will focus this study.

**Theoretical Framework of Learning**

The underlying philosophy of the SI model is a combination of three different learning strategies (a) behavioral, (b) cognitive and developmental, and (c) social interdependence (Hurley et al, 2006). The first principle SI employs are from the behavioral learning principles from Skinner (1982), Bandura (1977), and Ausubel (1967) and Herbart (1895). The following are four behavioral learning strategies the SI model utilizes (a) positive reinforcement, (b) breaking down complex tasks into their component parts, (c) emphasize cause and effect relationships, and (d) modeling is important (Hurley). With positive reinforcement, the students
learn a new strategy in the SI session about test taking. When students receive a good grade on a test, then the students continue to use the learned strategy. The second strategy is used when the content of a course becomes increasingly difficult. The SI leader takes on the challenge of breaking the concept down into smaller components. Once the content material is broken down, the students can understand. The third and the forth strategies complement each other by using the concept of modeling good study behaviors and strategies. The SI leader communicates models for good study tactics. As students use the tactics, good performances in classes both present and future result.

The second learning set of learning strategies that SI borrows are the cognitive and developmental principles of Brunner (1968), Piaget (1997), and Flower and Hayes (1981). The four cognitive developmental principles on which SI is based are: (a) cognitive structures develop little by little as learning is built through organization and assimilation of new information and experiences, (b) learners think differently about a concept as they assimilate knowledge, (c) prior knowledge is used while learning new knowledge, and) (d) cognitive development is stimulated when conflict arises during social interactions (Hurley et al., 2006). With cognitive development, the SI leader acts as a conduit for clarifying the concepts presented in class. For example, when presented with a new lesson in a mathematics class the students must find ways to understand the presented material. The instructor will present the ideas clearly and concisely but the students may not grasp the ideas at first. The SI sessions take the second round at organizing the material in different ways for students to understand. The SI leader helps students dissect the material into bits that are easier to understand, and shows how this new concept may connect to previous concepts learned in the course. The connections from old to new ideas create facilitate understanding. In the SI sessions, the SI leader does not relecture to
students. Instead, the students work together to help each other understand the given concepts of the daily and weekly lessons. Through working together, the students are not only learning the material but also helping their fellow students in the process.

The third set of learning strategies that SI draws on several social interdependence principles from Bakhtin (1993), Doyle (1983), Erickson (1982), Geertz (1983), and Vygotsky (1986). Five areas from which SI derives the social interdependence principles are: (a) learners actively build knowledge; (b) working together cooperatively and interdependently; (d) knowledge is more thorough when it is produced, not simply distributed; (e) knowledge and understanding are constructed in dialogue with others, and facts are “true” in that social situations; (f) learners are able to do in group effort today what they will be able to do autonomously tomorrow (Hurley et al., 2006). The five principles are the foundation of the SI learning process and are student-based. In the SI sessions, the students are the center of the learning process and actively engaged in learning the course concepts. In the group setting, the students can break down the social and academic barriers encountered in the classroom. The SI session turns into students helping students session and includes the SI leader. Through students helping each other, the student(s) can construct a dialogue, based on the material, and develop a true understanding of the material. This understanding helps solidify knowledge based of the course content. Thus, the group setting of SI creates an environment conducive to learning and promotes an overall understanding of necessary course material.

In each of the three learning strategies, SI is created. The theory behind this study is composed of ideas from the cognitive, developmental, and social interdependence of principles, which compose the theory of situated cognition. In the following section, I will discuss how the cognitive principles, as stated by Vygotsky (1978) apply to SI and the social interaction of
learning communities, as stated by Lave and Wenger (1991). Through theory, I have shown the social interaction that SI creates and the facilitation of learning. Thus, the learning communities of SI enabled students to complete difficult course work in college algebra at a technical college.

Social Constructivism

A prominent constructivist Lev S. Vygotsky, a Russian psychologist, proposed a model called the Zone of Proximal Development. The Zone of Proximal Development (ZPD) describes a zone or gap between where learners operate independently at a lower level and the level of more competent peers. More specifically, “This Zone is the distance between the actual developmental level as determined by independent problem solving and the level of potential developmental as determined through problem solving under adult guidance and under the direction of more capable peers” (Vygotsky, 1978, p. 86). He emphasized that through practice and interaction with more capable peers, like the SI leaders, learners are able to increase their ability to think. In addition, learners are consistently encouraged by the more competent peers in order to extend cognition to a higher level of thought (Vygotsky). He also observed collaborative learning activities created independent thinkers; this is a foundational element of Supplemental Instruction by students collaborating during the SI sessions.

The interaction and involvement of peers is central to SI and advocated by Vygotsky (1978). Interaction enables students to extend toward a higher level of cognition by making connections among topics learned in the classroom. During the SI sessions, the students have a place to learn how to make connections through the help of the SI leader (Arendale, 1994). The SI program assists students with basic learning skills, which allow students to increase the level of reasoning skills. The reason for the increase is due to students learning how to learn through the help of SI leaders modeling appropriate questioning and reasoning in the SI sessions (Martin
et al., 1992). The SI leader should follow the SI model, which stresses collaborative learning strategies (Whitman, 1988). In addition to helping students academically, the SI model uses collaborative learning to provide an ideal environment for students to be aware of the role of individual differences in learning situations, gain additional perspectives and study techniques, and work in a successful collaborative effort (Martin et al.).

**Perspectives**

In a typical classroom, the instructor is the one that actively sets the pace and content of the lesson.

The teacher, in a face-to-face-reasonably formal manner, tells, shows, models, demonstrates, teaches the skills to be learned. The key word here is *teacher*, for it is the teacher who is in command of the learning situation and leads the lesson, as opposed to having instruction “directed” by a worksheet, kit, learning center, or workbook.

(Baumann, 1988, p. 714)

While direct instruction has merit and is useful in the classroom, it may not be the best teaching method that for the learning needs of all students. To find a “best” method, researchers have hypothesized that students working together in groups could attain more success than on their own (Palincsar, 1998). Daiute and Dalton (1993) investigated how children 7 to 9 years old used collaboration to teach on another how to write. The peer collaboration between students resembled a teacher-student model, resulting in the creation of new story elements and better forms of writing than the students had alone. Another explanation into the use of peers in learning is that when a student explains their own thinking to another, deeper cognitive processing occurs (Scardamalia & Bereiter, 1989).
Another study on social cognitive theory, Bell, Grossen, and Perret-Clermont (1985) researched how children working with peers showed more cognitive growth than children alone. The conditions for this research were that of students actively engaged in problem-solving activities and not just observing the more advanced peer. However, there was a note of the level of the advanced peer, if he or she was too advanced for others in the group; he or she was not challenged. Instead, her answers were merely accepted. The process did not stimulate the students in the group.

Taylor and Cox (1997) were interested in characterizing the learning of mathematics as a social enterprise. Their theory was that children could construct and invent math competences instead of through direct instruction of modeling and imitating. The researchers placed the children into two peer interaction conditions of socially assisted learning and modeling along with classroom control. To guide the research the children were given word problems that focused on the representation of the problem instead of simply attaching numbers onto words. Included in the socially assisted learning were (a) use of a reflection board in which members could share publicly their representation of the problem, (b) peer collaboration, (c) reflective questioning, (d) scaffolding, (e) shared ownership, (f) quizzes, feedback, and rewards, (g) daily math lessons in the regular classroom (Taylor, & Cox 1997). The modeling group was similar, but it did not include reflective questioning, scaffolding, or shared ownership. The research indicated that the socially assisted group received higher scores than those in the modeling or control groups. In explaining the different outcomes, Taylor and Cox conjectured that the success with the social group was a function of the shared ownership of learning.

Social Learning Theory
With the SI sessions, an environment is in essence a community. The students that make up the SI session share a common interest in learning the material presented in the classroom. By sharing this interest, students become active and nonactive participants during the sessions. Because the community is without a “formal” structure, it takes on a more social setting. The only formality is the SI leader takes on the role of a facilitator in order to keep the students focused in the sessions. Through the sessions, the students create ways of learning the material in a social way instead of a formal way. The question is how the students learn in these situations. In the remainder of this section, the author reviewed different aspects of social learning theory in an attempt to answer how students learn in these communities.

Through different perspectives and research by Bandura (1977) and Lave & Winger (1991), peer tutoring promotes learning in students. This concept is the basis of SI. In SI, students help other students with an SI leader, who is also a student, to facilitate a learning community.

*Wenger’s Community of Practice*

In regards to social learning theory, Wenger (1998) stated four components about the social theory of learning. The components characterize social participation as a process of learning and of knowing. The components include:

(a) meaning: a way of talking about our ability – individually and collectively–to experience our in life and the world as meaningful; (b) practice: a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action; (c) community: a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence; (d) identity: a way of talking about how
learning changes who we are and create personal histories of becoming in the context of our communities (p. 5).

With the four components as a foundation to the SI sessions, the students begin to learn. Because the focus of the SI sessions is on the college algebra classroom, students must find meaning by becoming active participants. This may take the form of leading another student through a difficult computation or asking questions of the SI leader to lead the group. With the SI sessions and the classroom connections, the students become part of a community, which actively engages them in practice. Through practice, in both the SI sessions and on their own, students increase their knowledge base of the material.

_Situated Learning_

How do individuals learn? According to social learning theory, individuals learn best in social situations. Situations can be the local grocery store or the classroom. Social situations in a classroom might be a concern. Most instructional classes are extremely structured, to the point of no interaction, not even between the instructor and students. The instructor walks into the classroom, lectures about the topic of the day, and leaves immediately. This may not be the best environment for learning. Thus, social situations are needed to facilitate learning.

According to Lave and Wenger (1991), the “focus the relationship between learning and the social situations in which it occurs” (p. 14). They focused their research on ethnographic studies of social situations outside of the classroom and qualified the amount of learning that took place. A few of these situations were the calculation of food portions that dieters use in the Weight Watchers® program or the use of arithmetic practices in a supermarket. Both of these situations used basic arithmetic operations of fractions and decimals in both social and academic settings.
The authors Lave and Wenger “consider situated cognition as a ‘socialization’ theory – it is about how individuals become members of communities” (as cited in Schell & Schell, 2007, p. 24). The students in the classroom become a part of a community within that classroom space. This community dissects further when students take part in the supplemental instruction sessions. In addition, the SI leader uses the concepts of situated learning to facilitate the design and delivery of the SI sessions.

In the research of Schell and Black (1997), three key aspects of sociology are important for situated learning: (a) developing a community of practice, (b) encouraging intrinsic motivation, (c) maximizing cooperation within the community. In developing a community of practice, the SI sessions create a unity among the student participants. Intrinsic motivation to participate in the SI sessions is a student, self-directed aspect. The students must want to participate and take responsibility for their learning the material.

Review of Previous SI Research

The majority of the studies conducted on SI have been by the International Center for SI at the UMKC. This review examined only studies pertaining to mathematics or studies examining student retention at institutions of higher education in the United States.

Evidence Supporting SI Claims of Effectiveness

Arendale (1997) stated three claims for SI effectiveness:

Students participating in SI within the targeted historically difficult courses earn higher mean final course grades than students who do not participate in SI. This is true when differences are analyzed, despite ethnicity and prior academic achievement; Despite ethnicity and prior academic achievement, students participating in SI within targeted historically difficult courses succeed at a higher rate than those who did not participate in
SI; [and] Students participating in SI persist at the institution (reenrolling and graduating) at higher rates than students who do not participate. (p. 11)

To support these claims, data was used from studies at UMKC. Since 1980, UMKC has offered 525 courses with SI at the undergraduate, graduate, and professional school levels. The number of students in this study was 19,962 SI participants and 31,368 nonparticipants. The study indicated the final mean score and the participation rate in the SI sessions. The data suggested a use of t-test and chi-squares. Table 1 indicates a portion of the data for the fiscal year 1994-1995 to 1998-1999. Analysis of the data in Table 1 indicates that the grades and withdrawal rates of the SI participants earned a statistically higher mean final course grades and the percentage of A and B grades. Whereas, the Non-SI participants earned higher D, F, and W rates and lower mean final course grades (Center for Academic Development, 2003). The results were replicated over the 20-year study, from 1980 to 1999, in a variety of courses at different levels of the institution.

The researcher also analyzed the data for students who attended SI 5 or more times. there is statistically significant improvements with these comparison measures that favor the SI participants (Arendale, 2001).

Table 2 indicates the analysis of one semester at UMKC to view the number of times a student participated in the SI sessions and how it affected the final course grade. The students were grouped into categories based on the number of times they attended SI: never, 1 or more, 1 to 3e, 4 to 7, 8 to 11, and 12 or more times. The data from Table 2indicates that increasing the frequency of the SI sessions increases mean final course grades. There was one abnormality where the students who attended 12 or more sessions had a slightly lower mean final course grade. The researcher did state that from interviews with those students. It was found that the
student would have withdrawn but persisted through frequent attendance of SI sessions (Arendale, 1997).

Table 1

<table>
<thead>
<tr>
<th>Year</th>
<th>SI</th>
<th>SI Percent/Number</th>
<th>Number</th>
<th>SI of Participation</th>
<th>Percent SI A &amp; B</th>
<th>Percent D, F, &amp; withdraw</th>
<th>Final Course Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998-1999</td>
<td>SI</td>
<td>48.9% (2,010)</td>
<td>52</td>
<td>54.4% *</td>
<td>20.2% *</td>
<td>2.70**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-SI</td>
<td>51.1% (2,044)</td>
<td>42.9% *</td>
<td>33.8% *</td>
<td>2.43**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997-1998</td>
<td>SI</td>
<td>39.4% (1,700)</td>
<td>51</td>
<td>55.1% *</td>
<td>19.0% *</td>
<td>2.65**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-SI</td>
<td>60.6% (2,6006)</td>
<td>42.8% *</td>
<td>36.5% *</td>
<td>2.31**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996-1997</td>
<td>SI</td>
<td>45.4% (1,604)</td>
<td>47</td>
<td>55.9% *</td>
<td>16.7% *</td>
<td>2.66**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-SI</td>
<td>54.6% (1,929)</td>
<td>44.1% *</td>
<td>31.5% *</td>
<td>2.35**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995-1996</td>
<td>SI</td>
<td>40.0% (1,454)</td>
<td>41</td>
<td>52.0% *</td>
<td>21.6% *</td>
<td>2.64**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-SI</td>
<td>60.0% (2,181)</td>
<td>37.8% *</td>
<td>39.6% *</td>
<td>2.27**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994-1995</td>
<td>SI</td>
<td>36.3% (1,233)</td>
<td>41</td>
<td>52.6% *</td>
<td>21.6% *</td>
<td>2.64**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-SI</td>
<td>63.7% (2,330)</td>
<td>37.8%*</td>
<td>39.6%*</td>
<td>2.27**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Level of significance for differences: 0.05 chi-square test. ** Level of significance for differences: 0.01 independent t-test. From “Supplemental Instruction (SI); Review of Research Concerning the Effectiveness of SI from the University of Missouri-Kansas City and other Institutions from across the United States” by D. Arendale (2001). Annual Institutes for Learning Assistance Professionals,(pp. 11 - 12).
Table 2

*Frequency of SI Attendance Upon Mean Final Course Grades: Winter 1996 (N = 1,560)*

<table>
<thead>
<tr>
<th>Group Composition</th>
<th>Number</th>
<th>Percent Of A &amp; B</th>
<th>Percent Of D, F, &amp; W</th>
<th>Mean Final Course Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do No Attend Any SI Sessions</td>
<td>854</td>
<td>42.2%**</td>
<td>39.3%**</td>
<td>2.37*</td>
</tr>
<tr>
<td>Attended One or More Sessions</td>
<td>736</td>
<td>59.1% **</td>
<td>18.2% **</td>
<td>2.79*</td>
</tr>
<tr>
<td>Attended 1 to 3 SI Sessions</td>
<td>378</td>
<td>56.3% **</td>
<td>21.4% **</td>
<td>2.77*</td>
</tr>
<tr>
<td>Attended 4 to 7 SI Sessions</td>
<td>189</td>
<td>63.0% **</td>
<td>17.4% **</td>
<td>2.82*</td>
</tr>
<tr>
<td>Attended 8 to 11 SI Sessions</td>
<td>102</td>
<td>63.7% **</td>
<td>12.8% **</td>
<td>2.88*</td>
</tr>
<tr>
<td>Attended 12 or More SI Sessions</td>
<td>67</td>
<td>56.7%**</td>
<td>10.5%**</td>
<td>2.64*</td>
</tr>
</tbody>
</table>

*Note.* Level of significant of difference: 0.05 using chi-square test when comparing the baseline non-SI participant group and the individual SI-participant group. **Level of significance of difference: 0.01 using independent t-test when comparing the baseline non-SI participant group and the individual SI-participant. From “Supplemental Instruction (SI); Review of Research Concerning the Effectiveness of SI from the University of Missouri-Kansas City and other Institutions from across the United States” by D. Arendale (2001). Annual Institutes for Learning Assistance Professionals,(p. 15).

To go beyond UMKC, Arendale (2001) reviewed 270 institutions between 1982 and 1996, and examined the impact of SI with institutions of different broad academic areas. However, this study only involved mathematics. Table 3 indicates the information collected only from the math courses out of the 4,945 courses used in the study. From the field test of other institutions, the usage of SI in mathematics courses increased the mean final course grade than those who did not participate in the SI sessions.
Table 3

*National SI Field Data: FY 1982-83 to FY1995-96*

<table>
<thead>
<tr>
<th>Types of Courses</th>
<th>Percent</th>
<th>Percent</th>
<th>Final Course Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A &amp; B</td>
<td>D, F, &amp;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(chi-square test)</td>
<td>(chi-square test)</td>
<td>(independent t-test)</td>
</tr>
<tr>
<td>All Courses</td>
<td>SI</td>
<td>46.80%</td>
<td>23.10%</td>
</tr>
<tr>
<td>N = 4,945</td>
<td>Non-SI</td>
<td>35.90%</td>
<td>37.10%</td>
</tr>
<tr>
<td>p-value</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Algebra</td>
<td>SI</td>
<td>36.40%</td>
<td>37.50%</td>
</tr>
<tr>
<td>N = 219</td>
<td>Non-SI</td>
<td>35.20%</td>
<td>52.70%</td>
</tr>
<tr>
<td>p-value</td>
<td>0.05</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Calculus</td>
<td>SI</td>
<td>43.10%</td>
<td>32.40%</td>
</tr>
<tr>
<td>N = 143</td>
<td>Non-SI</td>
<td>37.20%</td>
<td>42.50%</td>
</tr>
<tr>
<td>p-value</td>
<td>0.05</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Finite</td>
<td>SI</td>
<td>45.60%</td>
<td>30.40%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Non-SI</td>
<td>31.50%</td>
<td>48.40%</td>
</tr>
<tr>
<td>N = 30</td>
<td>p-value</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

From “Supplemental Instruction (SI); Review of Research Concerning the Effectiveness of SI from the University of Missouri-Kansas City and other Institutions from across the United States” by D. Arendale (2001). Annual Institutes for Learning Assistance Professionals,(pp. 17 - 18).

At this point, previous studies indicated how SI improved final mean course grades for students participating in SI as compared to the Non-SI participants at UMKC. Arendale (2001)
continued to study the effectiveness of SI by comparing the number of students who reenrolled from one year to the next. Table 4 indicates the re-enrollment from one year to the next for both SI and Non-SI participants. The conclusion from the data shows that the number of students that re-enrolled was about 10 to 15% higher for SI participants. This data shows that SI does increase retention.

Now the focus of empirical research must turn from UMKC to other institutions. Martin, Blanc, and Arendale (1996) viewed the reenrollment rates at Glendale Community College in California. They reported success with SI in the calculus courses. One of the comments they received summarized the student response to SI.

What I really liked about the SI was that if I had any questions, Dr. Kolpas or the other helpers didn’t tell us the answer. Instead, they let us think about the problem, set it up, and solve it ourselves. I also liked the one-on-one help and the friends I made. And, as we all recall from our math classes, learning how to think about it and set it up is the key to solving it. (p. 3)

Through modeling and encouraging the students to work together as a community, the students not only learned the material but learned problem solving skills, which can be transferred from the math classroom to life skills. The authors researched 480 two-year public institution course reports in the national SI database that were available for analysis (Martin et al., 1996). The institutions were community or junior colleges from across the United States. The results of this study were statistically significant with respect to both percent of successful enrollments and grade point averages in targeted classes. In sum, the difference favored the SI participants by 20% (Martin et al.).
Table 4

*Reenrollment and Graduation Rates of UMKC Students Enrolled in SI Courses 1989 to 1996.*

<table>
<thead>
<tr>
<th>Term</th>
<th>Number</th>
<th>Examination</th>
<th>Student of</th>
<th>Graduation</th>
<th>Reenrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term SI</td>
<td>Examined</td>
<td>Offered for SI Impact</td>
<td>Group Students</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Fall 89</td>
<td>SI 386</td>
<td>7.80% 65.3%*</td>
<td>Non-SI 923</td>
<td>5.00% 56.7%*</td>
<td></td>
</tr>
<tr>
<td>Fall 90</td>
<td>SI 529</td>
<td>5.90% 70.1%*</td>
<td>Non-SI 1,162</td>
<td>8.10% 58.3%*</td>
<td></td>
</tr>
<tr>
<td>Fall 91</td>
<td>SI 795</td>
<td>4.80% 70.6%*</td>
<td>Non-SI 1,085</td>
<td>5.30% 63.6%*</td>
<td></td>
</tr>
<tr>
<td>Fall 92</td>
<td>SI 639</td>
<td>8.60% 70.6%*</td>
<td>Non-SI 1,221</td>
<td>8.70% 53.6%*</td>
<td></td>
</tr>
<tr>
<td>Fall 93</td>
<td>SI 699</td>
<td>5.20% 73.4%*</td>
<td>Non-SI 1,221</td>
<td>8.20% 55.3%*</td>
<td></td>
</tr>
<tr>
<td>Fall 94</td>
<td>SI 604</td>
<td>4.30% 72.4%*</td>
<td>Non-SI 926</td>
<td>5.10% 60.8%*</td>
<td></td>
</tr>
<tr>
<td>Fall 95</td>
<td>SI 619</td>
<td>5.50% 74.5%*</td>
<td>Non-SI 940</td>
<td>7.30% 58.2%*</td>
<td></td>
</tr>
</tbody>
</table>

From “Supplemental Instruction (SI); Review of Research Concerning the Effectiveness of SI from the University of Missouri-Kansas City and other Institutions from across the United States” by D. Arendale (2001). Annual Institutes for Learning Assistance Professionals,(p. 14).
Summary

In this chapter the author examined literature related to the SI program, and the effective in increasing academic success. The background of the SI program was discussed along with a description of the program, the roles of the SI leader, SI supervisor, and SI faculty member. From the background, the author discussed a description of the theoretical basis for the SI program, which leads to a discussion of Vygotsky, the social constructivist. His theories emphasized the guidance of students by their more capable peers. This concept of peers helping peers ties in to the SI philosophy. Through peer tutoring, the SI session create a learning community. The learning community allows student to not only increase learning the content of the course but also learn how to learn.
CHAPTER 3

METHOD

This chapter describes the methodology used to answer the research questions. The purpose of this study was to assess the effectiveness of supplemental instruction (SI) on the achievement of college algebra students at a technical college. College algebra was defined as a course that includes the topics of fundamental algebraic concepts, equations and inequalities, functions and graphs, linear and quadratic functions, polynomial and rational functions, and exponential and logarithmic functions (Technical College System of Georgia, 2008).

To ascertain the effectiveness of SI as an intervention, the following questions were addressed:

1. What are the achievement scores of college algebra students who either participated or did not participate in supplemental instruction?

2. Was there a statistically significant difference in achievement between those who participated in supplemental instruction as oppose to those who did not participate?

This chapter is divided into five major sections: (a) sample selection, (b) the design of the experiment, (c) treatment, (d) instrumentation, and (e) data analysis.

Sample Selection

The sample consisted of students from two college algebra courses out of eight courses taught during the spring 2009 quarter at one technical college in Georgia. The two courses were selected because both courses were 65-minutes in length, held 4 days per week during the morning, and taught by the same instructor. The Supplemental Instruction (SI) program included
both course-specific materials and instructor-specific techniques. Thus, the study used the same instructor for all students attending SI sessions to maintain the instructor-specific techniques required. The remaining six courses were taught either in another format or by a different instructor.

The study used an experimental research design. Random selection of students for involvement in the study did not occur as students in college algebra classes choose the specific course and section to attend. However, random assignment was used to place students in experimental or control groups. Students in the selected college algebra classes were asked to participate in the study by completing a consent form (see Appendix A). Participation provided an extra 5% toward the final course grade. From the completed consent forms, students were randomly assigned to either the control or experimental group. From the two classes used in this study, 56 students registered for one of the classes, and 51 students agreed to participate.

Control group members had access to academic support center tutors provided by the college, as well as their instructor for any clarification or help on course material. This level of support was available to all students. The experimental group was required to attend SI sessions once a week for 2 hours per session for a total of five weeks. For SI sessions to be considered useful, those in the experimental group had to attend 4 of 5 planned sessions (Sucher, 2009). According to researchers, approximately 30% of students enrolled in SI courses actually volunteer to participated in the program (Martin et al., 1992). However, for the experiment SI sessions were mandatory. Thus, students randomly assigned to the experimental group were required to attend 80% (or 4 of 5) of the SI sessions.
Design of Experiment

The experiment involved two intact classes of college algebra, but randomly assigned students into experimental and control groups. The experiment took place during the first 5 weeks of the spring 2009 quarter. At the end of the 5 weeks, students took an assessment, which covered all the course material since the beginning of the study. From the assessment, achievement was tabulated.

On the first day of classes, students were asked to volunteer for the study. All participants earned 5% toward their final course grade. Control group members were required to complete all practice exams given in the college algebra class. In addition, the control group students had free access to the Academic Support Center and their instructor for questions or help with difficult material. Experimental group students were required to attend at least 4 of 5 planned SI sessions. The sessions were held each Wednesday afternoon from 1:30 - 3:30 p.m. during the 5-week experimental period.

Prior to the first session, the SI leader attended two workshops in order to deliver the methodology prescribed by the SI program. The first workshop provided an overview of the SI program by reviewing the SI leaders’ manual. The SI manual is a copy from UMKC’s SI program (Center for Academic Development, 2003). The manual details the tasks of the SI leader, such as attendance in the targeted college algebra courses, strategies to conduct the SI sessions, and methods to integrate content and learning skills. The SI leader and the current researcher worked on the content delivered in class and SI sessions to ensure that procedures were followed. There was also a need for the SI leader to practice answering questions. The SI leader was given example problems to prepare for review at the second workshop. In the second workshop, the SI leader began by showing and explaining the problems. After the board practice,
it was time to discuss how to focus the sessions to reflect a community of learning. This was accomplished by allowing students to model proper methods of problem solving. Students then, in turn, reciprocated the methods that were seen in both the SI sessions and classroom.

Once sessions started, the SI leader began each session, as the leader knew exactly what transpired in the classroom because he sat through one section of the college algebra course for the duration of the study. As the sessions moved forward, the SI leader changed his role to allow the students in the sessions to take charge. Students in SI sessions did not sit and listen to another lecture. Instead, students were placed in groups depending on material discussed. Students were also encouraged to show their work on the board and to talk out the concepts that were difficult or confusing. If students began to show or state concepts incorrectly, the SI leader was there to guide them back to the correct ideas. The SI sessions created a community of learning through students switching roles from passive learners to one that facilitates his or her own learning (see Appendix D).

Treatment

Students in both college algebra classes used in this study were asked on the first day of class to participate. As part of this request, they completed an informational survey that asked for their age, prior math classes completed, and for those who were in the experimental group to denote times for availability to the SI sessions (see Appendix B). The SI leader conducted all SI sessions. In keeping with the SI model, the SI leader was a college student who had received an A or a B in college algebra. The SI leader’s primary activities were to attend all class meetings for one section of college algebra, take notes, do homework, and read all assigned materials, conduct one 120-minute study session per week throughout the experiment using strategies learned through the SI leader training workshops, and regularly met with the researcher for a
debriefing of SI sessions (Center for Academic Development, 2003). The debriefings included a discussion of SI session observations, creation and use of SI session handouts, a plan for future SI sessions to use a wide variety of learning strategies, and a notification to the researcher of problems or potential problems. To ensure that the SI leader used appropriate SI techniques, an observation record form was used (Kenny, 1988; see Appendix C). During the SI sessions, the researcher completed the observation form. After each SI session, the observations were discussed with the SI leader (see Appendix D). The debriefing sessions informed the SI leader of ways to improve sessions, and to give the students the best possible level of instruction.

Throughout the experiment, all students took two chapter exams and a midterm exam. The midterm exam was used to denote student achievement. After the midterm exam was administered, data was collected and analyzed.

**Instrumentation**

This experiment took place over a 5-week period. SI sessions were held once each week for 2 hours per session. Each session followed the SI model set forth by UMKC faculty (Center for Academic Development, 2003). Observations for each SI session were recorded (see Appendix D). At the end of the 5 weeks, all participants took an assessment in the form of a midterm exam. The questions on the assessment were matched to the learning objectives for college algebra, as established by the experts at the Technical College System of Georgia (2008) for the identified time period. To check the validity of this assessment, three fellow math instructors were asked to review the midterm. Their charge was to validate each question to its matching learning objective. The following is a list of objectives, as stated by TCSG (2008) that were covered by midterm:

1. solve linear equations,
2. solve application problems involving linear equations,
3. solve quadratic equations,
4. solve application problems involving quadratic equations,
5. solve linear inequalities,
6. define complex numbers,
7. perform arithmetic operations on complex numbers,
8. solve quadratic inequalities,
9. solve rational inequalities,
10. solve absolute value equations and inequalities,
11. set-up and solve problems with direct, inverse, and joint variations,
12. graph ordered pairs,
13. define relations and functions,
14. graph linear functions,
15. solve systems of linear equations with two unknowns,
16. solve application problems involving linear systems, and
17. graph conics, which include circles and parabolas.

All three instructors concurred that the questions on the midterm correlated with the list of objectives. A copy of the midterm with the appropriate objectives listed by each question is shown in Appendix E. The midterm contained 25 questions with at least 1 question per objective. Objectives 1, 10, 11, 12, and 17 had 2 questions each, and Objective 13 had 4 questions. The time limit for the students to complete the midterm was 65 minutes.
Data Analysis

The data collected from the midterm exam was analyzed using the Statistical Software Package for the Social Sciences (SPSS). The statistical procedures were manipulated to answer the following research questions:

1. What are the achievement scores of college algebra students who either participated or did not participate in supplemental instruction?

2. Was there a statistically significant difference in achievement between those who participated in supplemental instruction as oppose to those who did not participate?

To answer the first question descriptive statistics such as frequency, mean, and standard deviation were applied to describe the achievement scores between those who participated in SI and those who did not. To answer the second question an independent $t$-test was utilized to find a difference in achievement on the midterm assessment between those who participated in the supplemental instruction sessions and those who did not. To aid in the interpretation of potential statistically significant results, effect size coefficients were calculated. Effect size was defined as the strength of the observed difference between the mean scores on the midterm assessment by those who participated in SI and those who did not (Gall, 2007). The value of the effect size was calculated using a post hoc power analysis to calculate eta squared ($\eta^2$) to clarify the findings after the calculated $t$-test. If the $t$-test showed a significant result, then the effect size determined the practical significance of using SI.
CHAPTER 4

FINDINGS

The purpose of the study was to address the following questions:

1. What are the achievement scores of college algebra students who either participated or did not participate in supplemental instruction?

2. Was there a statistically significant difference in achievement between those who participated in supplemental instruction as opposed to those who did not participate?

This chapter presents the research findings for the study organized into two main sections. The first section presents the descriptive statistics to address measures of central tendency and variability of the achievement scores by summarizing frequencies, means, and standard deviations for SI participants and non-SI participants. The second section summarized the findings for each question in this study.

Description of the Sample

Descriptive statistics were used to address both sample characteristics and relationships among the variables under consideration. Descriptive statistics dealt with the measures of central tendency and variability by presenting frequencies, means, and standard deviations in terms of the achievement scores on the college algebra midterm.

At the beginning of the study, there were 40 students randomly selected for this study with 20 students in the SI group and 20 in the non-SI group. For this study, SI participation was defined as attending at least 4 of 5 or 80% of the SI sessions. The purpose of this study was to
view the effectiveness of SI on the achievement of college algebra students. At the end of the study only 24 students (60%) remained. In the SI group, only nine students (45%) went to at least four SI sessions and took the mid-term assessment. In the non-SI group, only 15 students (75%) took the mid-term assessment. With this high attrition rate, the internal validity was compromised due to mortality. This introduced bias into the results of this study in the form of treatment fidelity. The study was setup with an assessment after 5 weeks to assure a lower mortality rate than a full 10-week quarter. Unfortunately, there was still a high mortality rate. In addition, there is a possibility that the 9 students had an internal need to participate in the SI session and in turn had a higher level of achievement on the midterm assessment.

A brief discussion is needed regarding the demographics of the 24 students used to make comparisons. Table 5 indicates the descriptive information. Traditional students were between 18 and 21 years old, whereas a nontraditional student was 22 years of age or older. A nonminority student was of White, nonHispanic origin whereas a minority student was of Asian, African, or Hispanic origin according to the information provided by the students. A full-time student took a total of 12-quarter hours or more of classes whereas a part-time student took less than 12 hours of classes. A learning support student took at least one course on developmental math prior to taking college algebra whereas nonlearning support students took college algebra without any developmental math courses (DTAE, 2007).

**Gender**

Of the females who participated in this study, \((n = 6)\) 50% were in the SI group and \((n = 6)\) 50% were in the non-SI group. Comparatively, the males who participated in this study were
compromised of \( n = 3 \) 75% in the SI group and \( n = 6 \) 25% in the Non-SI group. The mean values of females between those in the SI group \( M = 82.3 \) versus those in the non-SI group \( M = 77.8 \) clearly showed that the SI group achieved a higher average score on the midterm exam. The mean values of males between those in the SI group \( M = 90 \) versus those in the Non-SI group \( M = 74.4 \) indicated that the SI group achieved a higher average score on the midterm exam.

Race/Ethnicity

For this study, the breakdown of ethnicity/race was into two different categories, minority and nonminority. Participants in the minority group had the background of Asian, African, and Hispanic (DTAE, 2007). Participants from the nonminority group were from a White background. The minority students who participated in this study, \( n = 3 \) 43% were in the SI group and \( n = 4 \) 57% were in the Non-SI group. Comparatively, the nonminority students who participated in this study were compromised of \( n = 6 \) 35% in the SI group and \( n = 11 \) 65% in the Non-SI group. In comparing those who participated in this study to those of the sample college, the nonminority comprised 64.9% of the sample college population, and those who were part the minority with 31.8% of the sample college population (DTAE 2007). The mean values for those in the minority group for those in the SI group \( M = 86.3 \) versus those in the Non-SI group \( M = 63.5 \) clearly indicated that the SI group achieved a higher average score on the midterm exam. For those in the nonminority group, the mean values between those in the SI group \( M = 84.2 \) versus those in the Non-SI group \( M = 80.2 \) indicated that the SI group achieved a higher average score on the midterm exam.
Table 5

*Demographics of the SI Group and Non-SI Group*

<table>
<thead>
<tr>
<th></th>
<th>Non-SI Group</th>
<th>SI Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td>Females</td>
<td>6</td>
<td>77.8</td>
</tr>
<tr>
<td>Males</td>
<td>9</td>
<td>74.4</td>
</tr>
<tr>
<td>Minority</td>
<td>4</td>
<td>63.5</td>
</tr>
<tr>
<td>Non-Minority</td>
<td>11</td>
<td>80.2</td>
</tr>
<tr>
<td>Traditional</td>
<td>13</td>
<td>76.8</td>
</tr>
<tr>
<td>Non-Traditional</td>
<td>2</td>
<td>69</td>
</tr>
<tr>
<td>Learning Support</td>
<td>10</td>
<td>72.4</td>
</tr>
<tr>
<td>Non-Learning Support</td>
<td>5</td>
<td>82.6</td>
</tr>
<tr>
<td>Full Time</td>
<td>13</td>
<td>76.8</td>
</tr>
<tr>
<td>Part Time</td>
<td>2</td>
<td>69</td>
</tr>
</tbody>
</table>

*Note.* *n* = the number in the sample for that group, *M* = Mean score on the midterm assessment, and *SD* = standard deviation on the midterm assessment.

*Age*

In this study, the ages of the students were placed into 1 of 2 groups. The first group was the traditional college age students of 18 to 21 years old. Those who were of age 22 and over were placed the nontraditional group (DTAE, 2007). The traditional students who participated in this study, (*n* = 6) 32% were in the SI group and (*n* = 13) 68% were in the Non-SI group. Comparatively, the nontraditional students who participated in this study were compromised of
(n = 3) 60% in the SI group and (n = 2) 40% in the Non-SI group. In comparison to the sample college, the traditional students made up 29.7%, whereas the nontraditional students were 70.3% of the student body during the 2007 fiscal year (DTAE, 2007). The mean values of the traditional group for those in the SI group (M = 87.2) versus those in the non-SI group (M = 76.8) indicated that the SI group achieved a higher average score on the midterm exam. For the nontraditional group, the mean values between those in the SI group (M = 80.3) versus those in the Non-SI group (M = 69.0) indicated that the SI group achieved a higher average score on the midterm exam.

**Enrollment Type**

The enrollment type for this study was defined as either full-time or part-time. Participants who were defined as full-time students took at least 12-quarter hours of coursework, whereas part-time students were defined as taking at most 12-quarter hours of coursework. The part-time students for both the SI and Non-SI groups each consisted of (n = 2) 50%. The full-time students assembled into (n = 7) 35% for the SI group and (n = 13) 65% for the Non-SI group. Even when compared to the sample colleges breakdown of enrollment type. It lists 37.2% of the students were full-time and 62.8% of students were part-time during the fiscal year 2007 (DTAE 2007). For the full-time students, the mean values between those in the SI group (M = 86.0) versus those in the non-SI group (M = 78.8) indicated that the SI group achieved a higher average score on the midterm exam. Also, the mean values of the part-time students between those in the SI group (M = 81.0) versus those in the Non-SI group (M = 69.0) indicated that the SI group achieved a higher average score on the midterm exam.
**Entrance Exam Score**

The entrance exam score data was each student's ASSET Algebra score. The students were placed into 1 of 2 groups, learning support and nonlearning support. The students were defined as nonlearning support, meaning that the student tested high enough to be placed directly into the college algebra course without any learning support, math coursework. The sample college deemed the cut-off score. The students who were defined as learning support means that they took a learning support, math course prior to taking college algebra. This could mean that a student took one, two, or three math courses prior to taking college algebra. The learning support students who participated in this study, \( n = 5 \) 33% were in the SI group and \( n = 10 \) 67% were in the Non-SI group. Comparatively, the nonlearning support students who participated in this study were comprised of \( n = 4 \) 44% in the SI group and \( n = 5 \) 56% in the non-SI group.

For the students in the learning support group, the mean values between those in the SI group \( (M = 81.4) \) versus those in the Non-SI group \( (M = 72.4) \) indicated that the SI group achieved a higher average score on the midterm exam. The mean values for those students in the nonlearning support made the comparison of the SI group \( (M = 89.3) \) versus those in the Non-SI group \( (M = 82.6) \) which indicated that the SI group achieved a higher average score on the midterm exam.

**Midterm Assessment Scores**

The midterm grades earned by the participants were calculated. The overall mean score on the college algebra midterm for the 24 was 79.1 with a standard deviation of 10.96. The SI participants earned higher grades on the midterm algebra than their Non-SI
counter parts. The SI participants earned a mean grade of 84.6 with a standard deviation of 10.37. The non-SI participants earned a mean grade of 75.8 and a standard deviation of 10.26. A \( t \)-test was calculated between the mean midterm grades of the SI and Non-SI students. The results were \( t(22) = -2.02, p = 0.06 \), which was not statistically significant at the alpha level of 0.05.

Question 1: What are the achievement scores of college algebra students who either participated or did not participate in supplemental instruction?

At the end of the 5-week experimental period students took a mid-term exam (see Appendix E), and completed a survey (see Appendix G) to denote whether they received help outside of the classroom. This survey questioned if students used the Academic Support Center or other types of outside help. The results showed that the students in the non-SI group did not use any outside sources of help or at least they did not admit to help outside of the classroom. It was noted that some of the students in the SI group used outside resources as well as the SI sessions. Table 4.2 lists the results of the midterm survey.

The scores utilized a percentage value with the maximum value of 100%. Because the calculations used a \( t \)-test, one of the assumptions was the current researcher was sampling from a normal distribution. When the \( t \)-statistic was calculated, the data were normalized. There was no difference between using the raw score and the percentage value. From the list of scores, the mean and standard deviation was calculated. For the Non-SI Group, the mean was 75.8\% with a standard deviation of 10.26. For the SI Group, the mean was 84.9\% with a standard deviation of 10.96.
Table 6

*Results of the Midterm Survey*

<table>
<thead>
<tr>
<th>Question</th>
<th>Non-SI Group</th>
<th>SI Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did you visit the Academic Support Center?</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>2. Did you use a private tutor?</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>3. Did you visit your instructor's office?</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>4. Did you attend the SI sessions on Wednesdays?</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

Question 2: Was there a difference in achievement between those who participated in supplemental instruction as oppose to those who did not participate?

An independent t-test was conducted to evaluate the achievement between those who participated in supplemental instruction as oppose to those who did not participate. The test was not significant, $t(22) = -2.0$, $p = 0.06$, at the alpha level of 0.05. Students in the SI group ($M = 84.9$, $SD = 10.96$) on average scored higher in achievement than those in the in the Non-SI group ($M = 75.8$, $SD = 10.26$). The 95% confidence interval for the difference in means was quite wide, ranging from -17.76 to 0.25. To answer the question, there was not a statistically significant difference in achievement between those who participated in supplemental instruction and those who did not at the alpha level of 0.05.
Summary

In this chapter, the data analysis for the research questions in this study organized into two sections was described. The first section described the findings via descriptive statistics to address measures of central tendency and variability of the achievement scores by summarizing frequencies, means, and standard deviations for SI participants and non-SI participants. The second section summarized the findings for each question in this study. The findings yielded no significant difference between those who participated in the SI program and those who did not.
CHAPTER 5

DISCUSSION

In this chapter, the study is summarized and conclusions are presented based on the results of this study and implications of the findings and possible directions for future research are discussed. The purpose of this study was to assess the effectiveness of SI as an intervention that may increase completion in college algebra in a Georgia technical college. SI was defined as a student academic assistance program that increases both academic achievement and retention rates (Arendale, 1994). SI traditionally targets difficult courses; those courses that have a noncompletion rate of 30% or more. At the technical college used in this study, college algebra was deemed as a difficult course. Blanc et. al. (1983) and Arendale (1994) claimed that SI assisted students to obtain higher grades than those who do not participate in SI.

In the present study, an experimental design was conducted to test the idea that students enrolled in a college algebra course who participated in the SI program would have higher achievement levels than those who did not participate. The participants who began the study were 40 technical college students at a single institution in the state of Georgia enrolled in two sections of college algebra during the spring 2009 quarter. After 5 weeks, only 24 students took the midterm assessment. There were 12 men and 12 women. Seventeen students were White, NonHispanic and 7 were from the minority group of Black, Hispanic, or Asian. The age ranged from 18 to 35 years of age. There were 20 full-time students and 4 part-time
students. Fifteen students took a learning support course prior to taking college algebra, and 9 who did not take a learning support course prior to taking the college algebra course.

This study was conducted in two sections of college algebra taught by the same instructor. There were 54 students in both sections, but only 40 students chose to take part in the study. Of the 40, 20 were randomly selected to be a part of the treatment group and the remaining 20 were the control group. By the end of the experiment, only nine were in the treatment group and 15 remained in the control group. Both groups received a midterm assessment at the end of the study and their grades were calculated. The results of data analysis led the researcher to conclude that there were no statistically significant differences between the groups’ achievement. In the following section, a discussion of the findings for this study is presented.

Discussion

In order to give a complete explanation of the findings it is important to state reasons why the data may or may not match with findings of similar studies. Researchers in SI have claimed, but have not empirically investigated the idea that SI sessions provide students with the opportunity to learn and develop appropriate learning strategies to result in increased achievement (National Center for Supplemental Instruction, 1997). However, the findings in this study were not consistent with the claims that SI helps students increase achievement level for the course attached to the SI program. There are several possible reasons for these findings. To this end, a discussion of treatment fidelity, attrition rate, and double exposure are discussed.

Treatment Fidelity

Treatment fidelity is defined as the strategies that monitor and enhance the accuracy and consistency of an intervention to: (a) ensure it is implemented as planned and (b) make certain
each component is delivered in a comparable manner to all participants over time (Smith, Daunic, & Taylor, 2007). As this study was planned, it followed the SI program as stated by UMKC with the modification of an experimental design. The original SI program had the intervention as a volunteer only program with a 30% participation rate of at least 2 or more sessions (Martin, 1992; Arendale, 2001). However, to maintain equality treatment across all participants, it was required that all participants in the experimental group attend at least 4 out of 5 SI sessions (Sucher, 2009). Of the 20 participants in the experimental group, 9 fit the requirements. Of the 9 participants, 5 attended 80% and 4 attended 100% of the SI sessions. The reason for the non-statistical significant result may be due to a high attrition rate rather than to lack of treatment fidelity.

Attrition Rate

An issue that must be addressed is the attrition rate. For an experimental design, the issue of mortality is a source of internal validity (Gall, 2008). The attrition rate for college algebra at the institution used in this study is about 40% (DTAE, 2007). Interestingly this study followed the attrition rate of 40% of those who totaled the final number of participants left in both groups who took the mid-term assessment. However, it needs to be mentioned that the experimental group had an attrition rate of 55%, and the control group had an attrition rate of 25%. Since the attrition rate of the experimental group was higher than the overall rate of the college and the control group, this may have led to the non-statistically significant result. But one cannot totally certain that if the attrition rate was lower there would have been a statistically significant result. The students who took part in this study were required to attend the SI sessions once a week for two hours. This is time that may be a hardship for some students to take on due to other outside issues such as other classes or work. At the beginning of the study, the students who agreed to
participate may not have realized that their lives would limit their ability to attend the SI sessions. If the students who stopped attending SI knew they could not take part, they may not have agreed to participate.

Another area that needs to be discussed is how affective is SI if only limited numbers of students attends the sessions. As an educator, I can see the benefit if only one student receives help in reaching their goal of completing their course in college algebra. SI is another form of intervention for students to improve their achievement levels. The students have made the first step in reaching their goals by enrolling in a technical college to locate a better job. But there are stumbling blocks such as the course work which may stop them from reaching their goals. One course that is a problem is college algebra which is why there is a need for a program like SI. If the students have access to SI and want to increase their knowledge base, then they will find time to attend. It is ultimately up to the students to make the choice of attending or not. However, this student was structured in the form of an experiment and gave rigid requirements on attendance. In the future, there could be a change from a once a week for two hours to possible twice a week for one hour.

_Treatment time._ One of the long standing claims of proponents SI is that it will increase the number of students increasing achievement of the course tied to the SI program by 15% to 20%. Being that this study was conducted during the first half of the spring quarter, which is only 5 weeks, if a different quarter was chosen, such as fall quarter, a different result might have occurred. In addition, the experiment was initialized at the technical college used in this study instead of viewing a SI program already in place. If a study was conducted over a longer period, such as a year, then the result may be different as the increase in time could allow for modifications in the SI program. An example of a modification could be the interaction of the SI
leader with the participants even though the participants change at the end of each quarter. If the same SI leaders were used, then they could learn how to increase the effectiveness of learning, similar to a teacher in a classroom.

*Involuntary assignment of participants to treatment groups.* SI was originally designed to be voluntary. For the purposes of this study, the experimental group was required to attend SI session once a week for 2 hours at a time. However, being active in learning demonstrates motivation and desire to participate, which has been recognized as a critical element in learning. Wood, Bruner, and Ross (1976) argued that this is vital to student engagement and ultimate learning. Without motivation and support of learning activities, students would not be willing to participate which is critical to acquiring knowledge. Freebody (2005) stated five phases students move through within the process of participation. Those phases are attention, stimulation, engagement, consistency, and pleasure.

Given the process described by Freebody (2005), it is possible that the motivational elements could have been compromised by the mandatory participation. Within the process of participation, attention, stimulation, and consistency may have been achieved due to the possibility of a higher grade. However, engagement and pleasure may have been potentially sacrificed in the present study by requiring only 1 group of students to participate in the activities of SI regardless of their motivation. Because SI is traditionally voluntary, those who took part in the program, as described in the literature, already do well in academic courses and were motivated to perform well prior to performance in the courses attached to SI. There is no reason to suspect that the proportion of motivated students in the SI group was different from their proportion in the control group. This situation may well account for the lack of differences in achievement between groups.
Double Exposure

It has been suggested that the success of the SI program is simply because it provides students with additional exposure to course content rather than the activities that develop appropriate learning behaviors. Double-exposure to course material is nothing more than additional time on task. Individual differences in time-on-task often equate directly to differences in new academic skills (Bloom, 1976).

The treatments used in this study, to some degree, involved additional exposure to course materials and concepts. SI sessions, although not structured or intended to be a reiteration of course materials, did revisit the course materials as they were presented. Instead of a regurgitation of the course materials, the students in the SI sessions learn behaviors and strategies from the SI leader. However, what is unacknowledged is demonstrating the most effective way to administer the information of the course content. Consequently, the SI program cannot escape the criticism that the improved academic achievement is tied only to the additional extra time-on-task.

Academic Characteristics of Participants

It is important to note that SI proponents advocate one of the strengths of SI is that it targets at-risk courses rather than at-risk students (Martin et al., 1992). For this study, college algebra was targeted and it is one of the highest at-risk courses at the technical college used in this study. Part of the reasoning college algebra is such a high-risk course is that many high-risk students take the course. For this study, 62.5% of the participants took a learning support math course prior to taking college algebra. Ramirez (1997) and Ogeden et. al (2003) stated that at-risk students are the greatest beneficiaries of SI programs. McCarthy et. al. (1997) found that in a mixed sample of regular and developmental students, the developmental students showed the
greatest amount of improvement while the regular students showed no significant improvement. In this study, neither the learning support students nor the nonlearning support students showed any statistically significant difference.

Sample Size/Attrition

A final explanation of the findings may be related to the 40% attrition in the sample between the beginning and end of the study. The non-SI group had a less attrition rate than those in the SI group. The SI group had a 55% attrition rate, and the Non-SI group had only a 25% attrition rate. Overall, the small sample size that this study began with had some effect on the conclusions drawn from the data in this study. The small sample size certainly lowered the power of the statistical tests carried out on the data with the result that the probability of these tests to detect a nonzero effect size was lower than it would have been if the sample were larger. Being that the largest a sample taken from the technical college at the time of the study would have been 76 students, which was still quite small, would not necessarily change the outcome, but taking data from at different time might have produced a different result. In short, the probability of the results of the statistical tests may have affected the variability of inferences made on the data when it was concluded that there was no difference in the achievement scores of the college algebra students who either participated or did not participate in SI.

Conclusions, Implications, and Directions for Future Research

Conclusions

Unlike the literature which praises the SI program (Arendale, 1994; Kenny, 1988), this study failed to find sufficient evidence to support that SI could increase achievement of college algebra students at a technical college in Georgia. It is suggested that SI should focus on high-risk courses, like college algebra, and not on high-risk students (Arendale). If the focus were on
high-risk students, then these students would not receive the advantages of exposure to their more advanced peers in a collaborative learning environment. However, the results of this study may support the focus being toward high-risk students. In this study, the experimental group of students experienced one extra session a week of exposure to course material through activities during the SI session. During the SI sessions, the students worked with their peers to discuss the course material of the week. The SI leader, who was a current student at the technical college and who was successful when he took the course, facilitated the sessions. During the five sessions that he presided over, he helped to create an environment that resembled a learning community. The students in the SI sessions were from two different college algebra sections with the same instructor, but all the students had the same goal of completing the course. During the SI sessions, the students were placed into small groups of about 4 or 5 to help students focus on concepts by completing problems from their college algebra course. The students would work together to complete the problems. If students were confused or did not know the next step, they had the SI leader to redirect them to the correct path. After the 5 weeks, all the students took an assessment, and their scores were tabulated. Unfortunately, this study did not produce statistically significant results, but the average scores showed that those students who participated in the SI group scored higher than those who did not. Those who participated scored on average 8.8% higher than those who did not participate. This shows a possible practical significance in that the students in the SI group had achieved a higher level of achievement than their non-SI counterparts did. Since there was not a statistically significant result, the potential practical significance of the higher achievement scores of the experimental group may be an anomaly.
To aid in the reasoning behind the higher scores the experimental group made on the mid-term assessment, a brief discussion need to be made regarding one of the central themes of SI, the interaction and involvement of student peers. Vygotsky in his Zone of Proximal Development (ZPD) also states this theme. He emphasized that through practice and interaction with more capable peers learners are able to increase their ability to think and to extend cognition to a higher level of thought (Vygotsky, 1978). During the SI sessions, the students collaborated in groups with a knowledgeable student of college algebra as the facilitator. The facilitator was the SI leader. As the students worked together, their knowledge expanded which is a possible reason for the mean score on the mid-term assessment of 84.6. Through working in collaborative learning environment, the students learned how to model different aspects of problem solving their college algebra concepts.

Respond to Research Questions

The purpose of this study was to address the following research questions:

1. What are the achievement scores of college algebra students who either participated or did not participate in supplemental instruction?

2. Was there a difference in achievement between those who participated in supplemental instruction as oppose to those who did not participate?

In the previous chapter, it was noted that there were no significant statistical differences between achievement of college algebra and participation in SI. There are a few reasons why there was no significant difference. Previous studies that had significant differences were conducted over longer time periods. Most of the studies were from colleges and universities that had SI already in place. This study was conducted over one-half of a quarter which was only 5 weeks long. The reason for the use of the shorten quarter was to increase the amount of validity
and decrease extraneous variables. A few extraneous variables needed to be addressed as possible reasons for the lack of significance. One is experimental mortality. Some of the participants dropped out of the study due to a number of reasons. One reason was that some students were not doing well in the course and stopped progress by withdrawing from the course. Others had more personal situations that needed to be addressed. They decided to withdraw or not take the midterm exam. Another extraneous variable that needs explanation is the John Henry effect. The students in the control or Non-SI group may have perceived that they were in competition with the experimental or SI group. However, all the students had the same goal of high achievement on the midterm assessment.

**Directions for Research**

As to the development of more students completing college algebra, future researchers may want to examine a longer period than 5 weeks of a quarter at a technical college. This is just a snapshot of time and a longer period, such as a yearlong study may show a significant result. Some important questions remain unanswered: Is the reported success of SI based on a longitudinal study only? Does SI help increase the knowledge gained by each student? Is SI just a model for double exposure and collaborative learning is a byproduct of the students attending the sessions?

This study revealed two important items. First, for students to have high levels of achievement in a college algebra course, it will take more than just attendance of the SI sessions as it was implemented in this study. Students may need more than just once a week session, but this may not be feasible for the students at a technical college on the quarter system. Second, it did not matter if a student was placed directly into the college algebra or into a learning support
course prior to taking the college algebra course. Students were not achieving in college algebra at a significant level regardless of their background.

Implications

The focus of this study was to assess the effectiveness of supplemental instruction (SI) on the achievement of college algebra students at a technical college. SI is defined as an academic assistance program that increases student performance and retention (Arendale, 1994). To increase student achievement, the SI program targets traditionally difficult or high-risk courses rather than high-risk students. A high-risk course is defined as one which has a D, F, or W rate of 30% or greater (Arendale). Because SI only targets high-risk courses, it eliminates the concept of a remedial program by providing regularly-scheduled, informal, review sessions in which students compare lecture notes, discuss course materials, develop organizational tools, and predict exam items. In the SI sessions, students learn how to integrate course content and study skills while working together in a group setting. By creating a group dynamic in the sessions, the students begin to break away from being dependent solely on the instructor. One of the goals of SI is to produce independent learners.

It is time to break the “dependency cycle” of learned behavior that allows students to remain dependent on the authority figure for their learning (Center for Academic Development, 2004). As shown in Figure 1, a new cycle emerged from SI. Students take charge of their learning through the SI Model in a cycle. The cycle starts with the instructor presenting new information. The students begin to process the new information, but they need help to assimilate it from the old information. The SI leader steps in to charge the students with discussions about the new information. The discussions could range from talking among the students to a student becoming the creator of new ideas. As the SI session progresses, the students become confident
of the new information and assimilate it towards previous information. The more familiar the students become with the new information, the information, then, no longer is new. This is when the students articulate the information as part of their knowledge (Burmeister & Carter, 1994).

**Observations from conducting the study.** From observing the SI sessions, students began to discuss with the researcher how the sessions were working for them. One student said that after a few sessions, he was receiving more information than just sitting in a tutoring lab. He noticed that by helping others he was gaining more knowledge of the subject matter. He even stated that at the beginning of the quarter, he dreaded going to the board to explain problems, but after two sessions no one could keep him from the board. He enjoyed the attention and the ability to explain the problem. This allowed him to do even better on his exams. During part of the SI sessions, the students were placed into groups where more advanced students are dispersed throughout the different groups. This allows the students in the groups to learn from each other. The only downfall is that some students do not realize that by showing others how to do a problem that they are gaining a higher level of understanding. The downfall is that this is not easily quantifiable.

Another student observation was from a student who as not a participant in the SI sessions. She was a student in the course, but did not take part in the sessions. One day she happened to sit at the back of the room during an SI session, but she did not stay long. She realized that even though she was from one of the classes that took part in the study, she did not belong. The SI sessions after a few meetings became a learning community. This community was created from the students who had the same ultimate goal of completing their college algebra course.
Another observation that occurred after the study ended. The SI leader became a tutor at the Academic Support Center (ASC) for the quarter following this study. While he was tutoring he implemented the techniques he learned while being the SI leader in the ASC. Being that at time in the ASC he would be the only tutor for approximately 20 or more math students. To help him work with all the students, he would place the students in groups according to the particular math course they were taking. One time he had two groups of students one for a basic math course and one for an elementary algebra course. To help answer all of their questions he placed them into two groups. This allowed for students to work with their fellow students even if they were not in the same class. Being that there was only one tutor, he could only answer one question at a time. Once he answered a question, he asked for the person who received guidance to help those around them answer the same or similar question. This is just one technique that he used to help the many students who visited ASC.

Contributions to solving the problem. The rationale of this study was to find a solution to the problem of students not achieving in college algebra. The SI program should have increased achievement. For this study it did not, but that does not mean that what transpired during the course of this project was for not. Those students who were in the experimental group received instruction that may stay with them in future course work. Through the interaction and involvement of peer students is central to SI and advocated by Vygotsky (1978), the sessions enabled the students to extend toward a higher level of cognition by making connections among topics learned in the classroom. During the SI sessions, the students had a place to learn how to make those connections through the help of the SI leader (Arendale, 1994). The SI program was designed to assist students with basic learning skills, which allowed students to increase their level of reasoning skills. The reason for this increase is due to students learning how to learn
through the help of SI leader modeling the appropriate questioning and reasoning during the SI sessions (Martin et al., 1992). The SI leader followed the SI model which stresses collaborative learning strategies (Whitman, 1988). In addition to helping students academically, the SI model uses collaborative learning to provide an ideal environment for students to be aware of the role of individual differences in learning situations, gain additional perspectives and study techniques, and work in a successful collaborative effort (Martin et al.).
REFERENCES


Pearson, K. (1900). On the criterion that a given system of deviation from the probable in the case of a correlated system of variables is such that it can be reasonable, supposed that have arisen from random sampling. Philosophical Magazine, 5(50), 157-175.


Rosenbaum, J. (2004). It's time to tell the kids: If you don't do well in high school, you won't do well in college (or on the job). American Educator, 28 8-21.


APPENDIX A

Supplemental Instruction Consent Form

I, _________________________________, agree to participate in a research study titled "The Impact of Supplemental Instruction on the Achievement of College Algebra Students at a Technical College" conducted by Ms. Alysen Heil from the Department of Occupational Studies at the University of Georgia (706-355-5064) under the direction of Dr. John Schell, Workforce Education, Leadership, and Social Foundations, University of Georgia (706-542-4206). I understand that my participation is voluntary. I can refuse to participate or stop participation without giving any reason, and without penalty or loss of benefits to which I am otherwise entitled. My decision to participate or not participate will not affect my grades or standing in any class. If I do decide to end participation I can ask to have all of the personal information about me returned to me, removed from the research records, or destroyed.

The reason for this study is to view the impact of Supplemental Instruction on achievement of students in college algebra. If I volunteer to take part in this study, I am subject to receive extra credit of 5% toward my final course grade at the discretion of the course instructor. If I do not choose to participate, I can still be subject to receiving 5% of extra credit toward my final course grade at the discretion of the course instructor. If I volunteer for this project, I will be randomly assigned to one of two groups: the non-supplemental and supplemental instruction group.

If I am placed in the non-supplemental instruction group, I am required to:
1) Not attend any extra tutoring sessions offered in this project. I understand that I will have access to all math tutors at the Academic Support Center.

2) Complete all of the practice exams online on the MAT 191 Thinkwell course site and allow the researchers to have access to these completed exams for research purposes.

3) Complete the College Algebra course for which you are enrolled as stated by the course syllabus and allow the researchers to have access to my completed assignments and exams for research purposes.

If I am placed in the supplemental instruction group, I am required to:

1) Attend tutoring sessions for 2 hours, once a week for a total of 8 sessions per quarter. (4 prior to midterm and 4 after midterm)

2) Sign the roll at each tutoring session.

3) Complete the College Algebra course for which you are enrolled as stated by the course syllabus and allow the researchers to have access to my completed assignments and exams for research purposes.

The tutoring sessions will be conducted by a current Athens Technical College student who has taken the course prior to this quarter and received an A or a B in the course. This student will have a good working knowledge of the subject.

The benefits for me if assigned to the supplemental instruction group are to potentially increase my ability in my college algebra course. Those in the supplemental instruction group should have an increased completion rate by about 10 to 15 percent more than those in the non-supplemental instruction group.
The researcher also hopes to learn more about the effectiveness of Supplemental Instruction as currently no technical colleges in the state of Georgia use this program. If this study proves to be successful in college algebra, then it could be used in other math courses as well as other courses that have low achievement rates. No risk or discomfort is expected.

No individually identifiable information about me, or provided by me during the research, will be shared with others without my written permission. I will be assigned an identifying number and this number will be used on all data calculations.

The investigator will answer any further questions about the research, now or during the course of the project.

I understand that I am agreeing by my signature on this form to take part in this research project and understand that I will receive a signed copy of this consent form for my records.

Ms. Alysen Heil .................................................................  __________
Name of Researcher                        Signature                  Date

Telephone: 706-355-5064

Email: aheil@athenstech.edu

_________________________     _______________________  __________
Name of Participant    Signature    Date

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 612 Boyd
Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu
APPENDIX B
Supplemental Instruction Survey

Name: ____________________________ Student Number: ________________

Birthdate: ________________ Email: ________________________________

Weekly Supplemental Instruction sessions will be offered for students enrolled in the course. This questionnaire will determine the most convenient times to schedule these sessions. Responses will be kept confidential, and will in no way be used to influence your grade for this course.

Directions: Please complete this survey even if you are not planning to attend the SI sessions.

1. How likely is it that you will attend SI for this course?
   ___ very likely ___ likely ___ neutral ___ not likely ___ very unlikely

2. Have you attended SI sessions before? ___yes ___no
   If yes, how useful did you find the SI sessions to be for helping you succeed in the course?
   ___ very likely ___ likely ___ neutral ___ not likely ___ very unlikely

3. Check one or more of the following reasons you are taking this course.
   ___ This course is required for my major.
   ___ This course satisfies an elective.
   ___ I am interested in this subject matter.
   ___ I enrolled in this course because SI is attached to it.
   ___ Other ____________________________________________________________________
4. What grade do you expect to make in its course? ___A ___B ___C ___D ___F

5. What grade do you want to make in this course? ___A ___B ___C ___D ___F

6. Please fill out the schedule below to help us determine the most convenient times to schedule SI sessions. Mark with an "X" the hours you know you would NOT be available for SI (work, class, etc.)

<table>
<thead>
<tr>
<th>Times</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
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<th>Saturday</th>
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</table>
Responses to Supplemental Instruction Survey

1. How likely is it that you will attend SI for this course?
   *Very Likely* 4
   *Likely* 7
   *Neutral* 20
   *Not Likely* 10
   *Very Unlikely* 10

2. Have you attended SI sessions before?
   *Yes* 0
   *No* 51

3. Check one or more of the following reasons you are taking this course.
   *This course is required for my major* 49
   *This course satisfies an elective* 2
   *I am interested in this subject matter* 8
   *I enrolled in this course because SI is attached to it.* 0

4. What grade do you expect to make in this course?
   *A* 24
   *B* 24
   *C* 3
   *D* 0
   *F* 0

5. What grade do you want to make in this course?
   *A* 45
   *B* 5
   *C* 1
   *D* 0
   *F* 0

6. From the Table, who is available for the SI sessions
   *Available* 24
   *Unavailable* 27
APPENDIX C

SI Leader Observation Record

SI Leader: ______________________________ Course: ________________________
Session Number: _____ Number Attending: _________ Observer: ________________

<table>
<thead>
<tr>
<th>Comment</th>
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<tbody>
<tr>
<td>Asks for student Questions</td>
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<td>Asks questions of students</td>
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<td>Answers questions from homework</td>
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<td>Answers questions by explaining concepts</td>
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<td>Answers questions by asking leading questions</td>
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<td>Gives practice quiz</td>
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<td>Delivers mini-lecture</td>
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<td>Refers to own class notes</td>
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<td>Refers to textbook'</td>
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<td>Refers to prepared notes</td>
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<td>Comments on note-taking skills</td>
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<tr>
<td>Comments on text-reading</td>
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<tr>
<td>Comments on time management</td>
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<tr>
<td>Comments on test prep/test taking</td>
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<tr>
<td>Comments on test analysis</td>
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<tr>
<td>Allows time for paired/group problem solving</td>
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<tr>
<td>Verbalizes own problem-solving thought processes</td>
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<tr>
<td>Attempts to establish relationships among concepts</td>
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<tr>
<td>Facilitates test review by pointing out major concepts</td>
<td></td>
</tr>
<tr>
<td>Facilitates test review by asking for likely concepts/problems</td>
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</tbody>
</table>

Comments:
The first day of SI tutoring had Chris a bit nervous. It was good that we had worked out a plan of what to discuss with the students, and then time students to work together on problems from the
week. It was interesting to observe students helping each other as they are still strangers to each other. Throughout the session, Chris circulated from group to group. When he found a problem that a group did not understand, he asked a volunteer to show everyone on the board. Of course no one wanted to go to the board, but there was one who did when asked by name. After the two hours, even Chris was amazed at how the students worked together in their groups, and how some students crossed over to other groups when classmates needed help.

The following is what was given to all students in attendance:

**SI Session—Day 1 Work**

1. Review Course Syllabus and Course Dates
   a. What is the policy on attendance? Is it important? Why?
   b. What is the policy on homework? Is it apart of your course grade?
   c. What is the policy on tests? How many? What type?

2. Review how to take notes
   a. Bring your workbook to class
   b. Print out the notes from Thinkwell if you don’t have your workbook
   c. Write down problems and state the page numbers if given
   d. If you did not understand a problem, stop Ms. Heil in class OR ask after class.
   e. DO NOT LEAVE THE CLASSROOM CONFUSED!

3. After class, review notes
   a. Rewriting or redoing problems covered in class – why would this help
   b. If you did not understand a concept or problem at home, ask MS. Heil or bring to SI.
   c. DO NOT WAIT too long to get a question answered
4. Homework
   
a. Do a section (10 problems) everyday on Thinkwell!

   b. Bring problems that you do not understand to class, the SI session, or visit MS.

   Heil’s office.

**Group Work.** The students were placed into 3 groups of 5 and were asked to complete the following problems:

1. A garden is 2.9 times as long as it is wide. It has perimeter of 101.4 feet. How wide is the garden?

2. Kim keeps candy in a small box on her coffee table. The length and width of the box are both 4 inches, and today there is a volume of 112 cubic inches of M & M's in the dish. Use the formula \( \text{Volume} = \text{length} \cdot \text{width} \cdot \text{height} \) to find the height of the M & M's.

3. Kim's Saturday morning jog follows a triangular path. Two legs of the path are equal, and the third leg is 4 miles shorter than each of the other legs. If the total path is 14 miles long, find the length of the third leg of the triangular path.

4. The perimeter of a triangle is 59 centimeters. The first side is 7 centimeters shorter than the second side. The third side is 4 centimeters shorter than double the length of the first side. Find the length of each side.

5. Find two consecutive even integers whose sum is three times the smaller integer

6. The product of two consecutive integers is –5 less than the square of the larger number. Find the smaller number.

7. To get an A in math, a student must score an average of 90 on five tests. On the first four tests, a student’s scores were 87, 95, 80, and 91. What is the lowest score that the student can get on the last test and still get an A?
8. Solve for \( x \): \( x + 6 = 2(4x - 4) \)

9. Solve for \( x \): \( 7(4 - 3z) + 3 = -6(z - 4) - 8 \)

10. Solve for \( x \): \( \frac{7 - 2x}{4} = \frac{3(x + 5)}{9} \)

11. Solve for \( z \): \( \frac{z - 4}{z + 3} = -\frac{29}{34} \)

12. Solve for \( x \): \( \frac{2}{5x - 1} = \frac{-4}{2x - 7} \)

13. Solve for \( x \): \( \frac{-3}{x} + \frac{3}{8x} = 5 \)

14. Solve for \( x \): \( \frac{-2x}{x + 4} - 3 = \frac{-3x}{x + 4} \)

15. Solve for \( x \): \( -16(x + 1) = -4(2 + 4x) \)

16. Solve for \( x \): \( \frac{12x - 8}{9x - 6} = -\frac{(x - 3)}{8x + 4} \)

17. Solve for \( x \): \( \frac{9}{x + 3} + \frac{1}{x - 5} = \frac{2}{x + 3} \)

18. Solve for \( x \): \( \frac{1}{x - 2} = \frac{3}{x + 2} - \frac{6x}{x^2 - 4} \)
### SI Leader Observation Record

**SI Leader:** Chris Lowen  
**Course:** MAT 191 College Algebra  
**Session Number:** 2  
**Number Attending:** 15  
**Observer:** Alysen Heil

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<td>Asks questions of students</td>
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<td>Answers questions from lecture material</td>
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<td>Answers questions from homework</td>
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<td>Answers questions by explaining concepts</td>
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<td>Answers questions by working an example</td>
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### Comments:

It was time to discuss test-taking techniques. The session began with the students getting into their groups of 5. Chris began the session by asking what types of problems the students were giving the students difficulty. It was a common consensus that word problem was the cause of their fear towards their first exam. It was unanimous that after they discussed how to take a multiple-choice exam they would look at how to tackle word problems.
They began by working within their groups but the room just became quiet. So, they worked together as one big group with one student at the board. Starting with #1, Jack read the problem to the whole class, and then asked what to write on the board. Sara said that it was a mixture problem and the formula used in mixture problems. This helped Jack with the setup of the problem. Once the problem was setup, he was able to solve with no problems. On problem #2, they worked in their groups since it was similar. With a little nudging in their groups from Chris, the SI leader, they were able to solve it without any problems. Problem #3 was discussed in the 12:15p.m. class, so it was up to the students from that class to explain how to setup and solve. It was good to hear how the students interpreted what their instructor did in class. On to problem #4, the type is a completion problem. The students discussed how to setup this problem. Since they were having problems conceptualizing, Chris had to step in to help the students. The main questions were, what do you know and what are you trying to find. The students started by stating the formula they needed to use. After a few moments of discussion in regards to the setup of the problem, they stumbled on the proper setup. Once the problem was setup, solving the problem was easy for the students. The students were then asked to work on problem #5 in their groups as it was similar to #4. The students were having trouble seeing the similarity, which is a problem with word problems. Again Chris, the SI leader had to step in and intervene. After the students setup the problem on the board, they could solve it without difficulty.

**Group Work.** The students were placed into 3 groups of 5 and were asked to complete the following problems:
SI Session – Day 2 Work

1. Discuss Test Taking Techniques.

   a. If you did not know how to solve a problem on a multiple choice test, what would you do?

      Example 1:

      \[
      \frac{x + 2}{4x + 8} = \frac{1}{7 - x}
      \]

      (a) -11   (b)  -3   (c) 3  (d) 8  (e) None of the above

      1. After reading the problem, notice the answer choices. Parts (b) and (c) only differ by a negative

      2. What could be a good first step? Cross multiply, simplify one of the fractions??

      3. If you cross multiply, \((x + 2)(7 - x) = 4x + 8\)

      4. Then simplify, \(7x - x^2 + 14 - 2x = 4x + 8\) \(\Rightarrow -x^2 + x + 6 = 0\), this gives a quadratic and we don’t know how to solve a quadratic.

      5. What to do, what to do??

      Example 2:

      Which is a solution of the system of equations?

      \[
      \begin{align*}
      x + 2y + z &= 9 \\
      2x + 2y - z &= 18 \\
      x - y - z &= 4 \\
      \end{align*}
      \]

      (a) (6, 3, -3)   (b) (5, -3, 10)   (c) (5, 3/2, -1)   (d) (5, 3, -2)  (e) None of the above

      (1) After reading the problem and the answer choices, what would be a possible answer(s)?
(2) How would you use your knowledge of answer choices to check for the correct one?

b. **How do you problem solve a word problem?**

Example 3:

A runner is training by sprinting up a long hill then slowly jogging down. He runs up hill at 240 meters per minute and comes back down at 160 meters per minute.

If one circuit up and back takes 30 minutes, how long is the hill?

(a) 2400 m  (b) 2880 m  (c) 3600 m  (d) 6000 m  (e) None of the above

1. Can we use some problem solving skills to solve this problem?

2. If we assume that it takes 15 minutes each direction then going up the hill would give us a distance of 240(15) = 3600 m and going down the hill would give us a distance of 2400 m

3. BUT the time is not equally split, which answer choice would be correct?

c. **If you want to double check your answers what could you do?**

Example 4:

Solve for \( x \):

\[-(3 + x) - (7 - x) - 3 = -(2 - x) + (-x) + 1\]

(a) 3  (b) -7  (c) 6  (d) There is no solution; this is a false statement  (e) None of these

1. This one may need to be simplified the old fashioned way by using your order of operations

2. What happens when you simplify? Answer?

3. How can we check that this answer is the right one?

Now it is your turn to try the techniques we just talked about in your groups.
1. After Terri wins a $100,000 payout in the lottery she donates 20% to charity, gives 25% to her family and friends, spends 14.5% on herself, and pays 30% in taxes. The remainder is in accounts earning simple interest of 14% and 11%. If her total interest is $1335, how much is in each account?

(a) $4000 at 14%; $4500 at 11%
(b) $5000 at 14%; $5000 at 11%
(c) $6000 at 14%; $4500 at 11%
(d) $7000 at 14%; $3500 at 11%

2. Ann has 32 oz. bowl of M&Ms on her coffee table. The candies are 50% blue M&Ms. She eats some of the M&Ms (which are 50% blue), then fills the bowl back to 32 oz. with a package of M&Ms that contains 20% blue ones. If the resulting full bowl (32 oz.) contains 40% blue M&Ms, how many ounces did she eat?

(a) 3 1/2 oz
(b) 6 1/3 oz
(c) 8 1/3 oz
(d) 10 2/3 oz

3. Thelma and Georgia are shopping in the city. Thelma leaves for home in her car at 4:00 traveling at 54 miles per hour, but Georgia doesn’t leave until 4:10. If she drives at 64 miles per hour, how long after she leaves does she catch up with Thelma?

(a) 10 min
(b) 32 min
(c) 54 min
(d) 60 min
4. One press can run the day’s newspapers in 6 hours, while another can do the same job in 8 hours. After running together for 2 hours to complete the job, the faster one breaks. How much longer must the slower press run to finish the newspapers?

(a) 3 hr 20 min
(b) 4 hours
(c) 5 hr 40 min
(d) 7 hours

5. Two salesmen are visiting houses to sell vacuum cleaners. Together, they can stop at every house in a neighborhood in 2 days, but one salesman covers twice as many houses as the other. If they work together for one day, how long will the slower salesman take to finish the neighborhood?

(a) 2 days 12 hours
(b) 3 days
(c) 3 days 12 hours
(d) 4 days
### SI Leader Observation Record

**SI Leader:** Chris Lowen  
**Course:** MAT 191 College Algebra

**Session Number:** 3  
**Number Attending:** 7  
**Observer:** Alysen Heil

<table>
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<td>Asks questions of students</td>
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<td>Answers questions from lecture material</td>
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<td>Answers questions from text material</td>
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<td>Answers questions by working an example</td>
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**Comments:**

Session 3 begins with students grumbling about the test. They did not like all the word problems. But they did say that they enjoyed the new material and that it was easy. So, the students began in their groups. Because there were only 7 students, they broke into 2 groups. The students were able to complete the given problems in their groups with great ease.
SI Session – Day 3 Work

1. Does anyone have any questions? Homework? Lecture?

2. Complex Numbers – They are not so complex.
   a. What is $i$?
   b. What is $i^2$?
   c. What is $i^3$?
   d. What is $i^4$?
   e. What is $i^{1088}$?

3. Simplify $4 + \sqrt{-256}$

4. Simplify $\frac{7i - \sqrt{-81}}{3 + 6i}$

5. Simplify $\frac{2 + 4i}{2 + 4i}$

Simplify the following:

6. $(x - 1)^2 = $

7. $(x - 2)^2 = $

8. $(x - 3)^2 = $

9. $(x - 4)^2 = $

10. $(x - 5)^2 = $

11. $(x - b)^2 = $

12. $(x + 1)^2 = $

13. $(x + 2)^2 = $
14. \((x + 3)^2 =\)
15. \((x + 4)^2 =\)
16. \((x + 5)^2 =\)
17. \((x + b)^2 =\)

For problems 18 – 20, factor the left side of the following equation by finding its perfect square trinomial. A perfect square trinomial is what you expanded your expressions on the previous twelve examples. Once you have factored the equation, how would you solve the factored equation?

18. \(x^2 - 10x = 8\)
   
   \(x^2 - 10x + (\underline{\_})^2 = 8 + (\underline{\_})^2\)
   
   \((x - \underline{\_})(x - \underline{\_}) = 8 + (\underline{\_})^2\)
   
   \((x - \underline{\_})^2 = 8 + (\underline{\_})^2\)

19. Solve by completing the square: \(x^2 + 8x = -2\)
20. Solve by completing the square: \(x^2 + 18x = 5\)
21. Solve by completing the square: \(2(x^2 - 6x) = 7\)
22. Solve \(x^2 - 4x - 12 = 0\) by factoring.
23. Solve \(x^2 - 4x - 12 = 0\) by completing the square.
24. Solve \(x^2 - 4x - 12 = 0\) by the quadratic formula.
25. Solve \(x^2 + 4 = 0\) by taking square roots.
26. Solve \(x^2 + 4 = 0\) by the quadratic formula
27. Solve \(4 + 12x - 2x^2 = -10\) by factoring.
28. Solve $4 + 12x - 2x^2 = -10$ by completing the square.

29. Solve $4 + 12x - 2x^2 = -10$ by quadratic formula.

30. Is there a reason to use factoring vs. the quadratic formula?
The fourth SI session is another test taking session. Because the tests were multiple choice, Chris did discuss some techniques in taking this type of test. One of the techniques was to make an educated guess if you go completely blank by eliminating potentially wrong answers. To help the students out, they were placed into 3 groups of 4 students each. As a collective, the students went through the handout by taking turns as to who went to the board to work each example. After
each example the students turned to their groups and practiced on given problem. The first group
to complete the problem designated a person to go to the board and show the remainder of the
class.

SI Session – Day 4 Work/Handout

1. Discuss Test Taking Techniques.

   a. If you did not know how to solve a problem on a multiple choice test, what
      would you do?

   Example 1:

   Solve for $x$, given the following right triangle:

   ![Diagram of a right triangle with sides labeled $x$, $3x-2$, and $2(x+1)$]

   (A) 4  (B) No Solution  (C) 7  (D) 5  (E) None of the above

   (1) Is there a formula for this problem? If so, what is it?

   (2) If you go blank, what could you do??

   Now you try the following problem in your groups:

   Solve for $x$ in the right triangle.

   ![Diagram of a right triangle with sides labeled $x$, $x + 14$, and 26]

   (A) 10  (B) 12  (C) $2\sqrt{15}$  (D) 24  (E) None of the above
Example 2:

If you have a quadratic equation, how should you solve it?

Solve for \( w \).

\[ w^2 - 4w - 5 = 0 \]

(A) \(-5\) or \(-1\)  (B) \(-5\) or \(0\)  (C) \(-5\) or \(1\)  (D) \(-1\) or \(5\)  (E) None of the above

(1) After reading the problem and the answer choices, what would be a possible answer(s)?

(2) How would you use your knowledge of answer choices to check for the correct one?

Now you try in your groups:

Solve for \( z \):

\[ z^2 - 2z - 24 = 0 \]

(a) 2 or 0  (b) 6 or -4  (c) 7 or -3  (d) \(1 + 2\sqrt{6}\) or \(1 - 2\sqrt{6}\)  (e) None of the above

Example 3:

Use Completing the Square: Solve for \( x \):

\[ x^2 + 10x + 1 = 0 \]

(A) \((x - 5)^2 = 4\)  (B) \((x + 5)^2 = 10\)  (C) \((x + 5)^2 = 24\)  (D) \((x + 5)^2 = 144\)

(1) After reading the problem and the answer choices, what would be a possible answer(s)?

(2) How would you use your knowledge of answer choices to check for the correct one?

Now you try in your groups:

Use Completing the Square to solve for \( w \):

\[ 3w^2 + 2w = -1 \]

(A) \(\left(\frac{w + \frac{2}{3}}{\frac{1}{3}}\right)^2 = \frac{-4}{9}\)  (B) \(\left(\frac{w + \frac{1}{3}}{\frac{1}{3}}\right)^2 = \frac{-2}{9}\)  (C) \(\left(\frac{w + \frac{1}{3}}{\frac{1}{3}}\right)^2 = \frac{2}{9}\)  (D) \(\left(\frac{w + \frac{1}{3}}{\frac{1}{3}}\right)^2 = \frac{4}{9}\)
Example 4: What about Square Roots???

Solve for w. \( \sqrt{14 - w} = w + 6 \)

(A) 2 or 11  (B) -2  (C) -5 or -10  (D) -2 or -11  (E) None of the above

(1) Can we use our test taking techniques to answer this problem?

(2) How?

You try the following in your groups:

Solve for w. \( \sqrt{3w + 1} - 3 = \sqrt{w - 4} \)

(A) -7 or 5  (B) 5  (C) 4 or 8  (D) 5 or 8  (E) None of the above

Example 5: How do you problem solve a word problem?

After his final exam, a student goes to the top of a building and throws his book into the air.

The height \( h \) in feet of the book above the ground is given by: \( h = -16t^2 + 32t + 128 \). How long is the book in the air?

(A) 8 seconds  (B) 6 seconds  (C) 4 seconds  (D) 2 seconds  (E) None of the above

> > Can we use some problem solving skills to solve this problem?

Now you try in your groups:

A company finds that its profits can be modeled with the formula \( P = 67.2x - 4.2x^2 \) where \( P \) is the profit in millions of dollars and \( x \) is the production (in thousands of units). At what production level(s) are the profits $100 million?

(A) 7.0 or 60.2 thousand  (B) 1.7 or 14.3 thousand  (C) 4.2 or 67.2 thousand  
(D) 16 thousand  (E) None of the above

> > If you want to double check your answers what could you do?
Example 6: How do you solve equations with rational exponents?

Solve for y:

$(3y)^{\frac{5}{3}} = (21y + 18)^{\frac{5}{3}}$

(A) -6/7  (B) -3 or 3  (C) -1  (D) -2/3 or 3  (E) None of these

(1) How do you even begin to solve this equation?

(2) Once you find a solution how do you check?
Today, students need help with preparing for their midterm, so more practice on test-taking techniques. To help the students remember all the types of problems, Chris, the SI leader, asked the students what they have covered so far this quarter. They listed linear and quadratic equations, word problems, graphing, functions, circles, and parabolas. They began the handout by going through the first nine examples together as one group. Then it was off to work in their groups for the remainder of the time. If a group did not understand a problem, they elected a
person to go to the board for help. The remainder of the students was asked to help the person at the board. The students would take turns at the board helping each other understand the material.

**SI Session – Day 5 Work/Handout**

It is time for your midterm exam. What topics have we covered since the beginning of the quarter?

Let's work our way backward to review:

1. Define Relations and Functions.
   a. What is the definition of a function?

Example 1: At what values of $x$, if any, does the following graph fail the vertical line test for functions?

![Graph of a function](image)

Example 2:
Which of the following statements is true regarding the graph below?

The graph is a function because it passes the vertical line test.

The graph is not a function because it is undefined at \( x = 0 \).

The graph is not a function because it fails the vertical line test at \( x = 0 \).

The graph is not a function because it fails the horizontal line test at \( y = 0 \).

2. Graph the equations:

Example 3: Graph \( 3x - 5y = 15 \)

Example 4: Graph \( y = -2(x - 1)^2 + 1 \)
Example 5: Graph \((x + 4)^2 + (y - 3)^2 = 25\)

3. **Circles:**

Example 6:

*Find the standard equation of the circle with radius 3 and center at \((-4, 2)\).*
11.

4. Absolute Value

Example 7: Solve for $x$: \[ \left| \frac{5}{x + 2} \right| = 7 \]

(A) 9/7 or -19/7  (B) -9/7 or -19/7  (C) 3/7 or -3/7  (D) 3/7 or -1

5. Inequalities:

Example 8: Solve for $x$: \[ \frac{6x - 7}{x - 3} \geq \frac{2}{x - 3} \]

(A) \((-\infty, \frac{3}{2}] \cup [3, \infty)\)  (B) \((-\infty, \frac{3}{2}] \cup (\frac{3}{2}, \infty)\)  (C) \((-\infty, \frac{3}{2}] \cup (3, \infty)\)  (D) \(\left[\frac{3}{2}, 3\right]\)

Example 9: Solve for $w$: \[ \frac{3}{4w - 1} < -\frac{1}{w} \]

(A) \(\left(\frac{1}{7}, \infty\right)\)  (B) \((-\infty, 0) \cup \left(\frac{1}{7}, \frac{1}{4}\right)\)  (C) \(\left(0, \frac{1}{4}\right) \cup \left(\frac{1}{7}, \infty\right)\)

Example 10: Solve for $p$: \[ 2p^2 - p - 15 \geq 0 \]

(A) \(\left[\frac{3}{2}, 3\right]\)  (B) \((-\infty, -3] \cup \left[\frac{3}{2}, \infty\right)\)  (C) \([-5, 3]\)  (D) \((-\infty, -\frac{3}{2}] \cup [3, \infty)\)

6. Other topics from the previous 2 tests:

1. The power in an electric circuit varies inversely with the resistance. If the power is 1200 watts when the resistance is 12 Ohms, find the power when the resistance is 6 Ohms.

2. Kepler’s law states that if one object is in orbit around another, the square of the time it takes that object to complete a revolution varies directly with the cube of the average radius of the orbit. How is the time affected if the average radius is doubled?

3. Solve for $z$: \[ \frac{3z}{5} + 2 = \frac{7(z + 1)}{8} \]
4. Solve for \( x \):
\[
\frac{2x - 4}{x + 2} = \frac{2x - 11}{x + 1}
\]

5. A cone has volume \( V = \frac{1}{3} \pi r^2 h \) where \( r \) is the radius of the base and \( h \) is the height. If a cone has a volume \( 108\pi \) cm\(^3\) and the radius is 9 centimeters, find its height.

6. A runner is training by sprinting up a long hill then slowly jogging down. He runs uphill at 240 meters per minute and comes back down at 160 meters per minute. If one circuit up and back takes 30 minutes, how long is the hill?

7. One fifth of the sum of two consecutive integers is 10 less than the smaller integer. Find the integers.

8. Andy bikes an average of 45 miles per day, five days a week. If he has already been on bike rides of 20, 40, 48, and 62 miles this week, how long does his last ride of the week need to be?

9. Solve for \( z \) by completing the square:
\[
z^2 - 2z = 24
\]

10. After his final exam, a student goes to the top of a building and throws his book into the air. The height \( h \) in feet of the book above the ground is given by: \( h = -16t^2 + 32t + 128 \). How long is the book in the air?

11. A yo-yo factory has fixed operating costs of $5000 per day plus costs of $2 per yo-yo produced. If a yo-yo sells for $5.50, what is the minimum number that must be sold in a day to earn a profit?
APPENDIX E

Midterm Assessment and Objectives

Objective 1: Solve Linear Equations

1. Solve for $z$: $4(2z - 5) = 7(z + 3)$
   
   a. $41$  
   b. $1$  
   c. $-1$  
   d. $5$

Objective 1: Solve Linear Equations

2. Solve for $y$: $\frac{3(y - 2)}{5} = 1 - 3y$
   
   a. $\frac{11}{6}$  
   b. $\frac{11}{18}$  
   c. $\frac{-11}{18}$  
   d. $\frac{7}{6}$

Objective 2: Solve Application Problems Involving Linear Equations

3. A 12-ft. board is cut into 2 pieces so that one piece is 4 feet longer than 3 times the shorter piece. If the shorter piece is $x$ feet long, find the lengths of both pieces.
   
   a. shorter piece: 32 ft.; longer piece 36 ft.  
   b. shorter piece: 12 ft.; longer piece 40 ft.  
   c. shorter piece: 2 ft.; longer piece 10 ft.  
   d. shorter piece: 6 ft.; longer piece 36 ft.

Objective 3: Solve Quadratic Equations

4. Completing the square: $x^2 + 4x = 7$
   
   a. $(x - 1)^2 = 28$  
   b. $(x + 2)^2 = 11$  
   c. $(x + 2)^2 = 14$  
   d. $(x - 2)^2 = 28$

Objective 4: Solve Application Problems Involving Quadratic Equations

5. A common equation used in business is a demand equation. It expresses the relationship between the unit price of some commodity and the quantity demanded. In the demand equation $p = -x^2 + 105$, for a certain style of calculator, $p$ is the price per calculator in dollars and $x$ is the
quantity demanded in thousands. Find the demand for the calculator if the price is $5 per calculator.

a. 10 thousand units  b. 80 thousand units  c. 11 thousand units  d. 50 thousand units

Objective 5: Solve Linear Inequalities

6. Solve the inequality: \(-5(y - 7) < -35y + 30\)

a. \((-\infty, -13]\)  b. \((-1, \infty)\)  c. \((-\infty, -1)\)  d. \((-\infty, -5)\)

Objective 6: Define Complex Numbers

7. Simplify \(\sqrt{-240}\) and write in terms of \(i\).

a. \(-4\sqrt{15}\)  b. \(4\sqrt{15}\)  c. \(4i\sqrt{15}\)  d. \(-4i\sqrt{15}\)

Objective 7: Perform Arithmetic Operations on Complex Numbers

8. Simplify \(\frac{5 + 8i}{9 - 5i}\)

a. \(\frac{85}{106} - \frac{47}{106}i\)  b. \(\frac{5}{56} - \frac{97}{56}i\)  c. \(\frac{5}{106} + \frac{97}{106}i\)  d. \(\frac{85}{56} + \frac{97}{56}i\)

Objective 8: Solve Quadratic Inequalities

9. Solve the inequality: \(x^2 - 7x \geq -12\)

a. \((-\infty, 3] \cup [4, \infty)\)  b. \([4, \infty)\)  c. \((-\infty, 3]\)  d. \([3, 4]\)

Objective 9: Solve Rational Inequalities

10. Solve the inequality: \(\frac{3x}{3-x} \geq 3x\)

a. \([3, \infty)\)  b. \([0, 2] \cup [3, \infty)\)  c. \((-\infty, 0] \cup [2, 3)\)  d. \((-\infty, 2] \cup [3, \infty)\)

Objective 11: Set-up and Solve Problems with Direct Variation
11. The distance that an object falls when it is dropped is directly proportional to the square of the amount of the time since it was dropped. An object falls 288 feet in 3 seconds. Find the distance the object falls in 4 seconds.

a. 512 feet  
   b. 12 feet  
   c. 384 feet  
   d. 128 feet

Objective 11: Set-up and Solve Problems with Inverse Variation

12. If the voltage, \( V \), in an electric circuit is held constant, the current, \( I \), is inversely proportionally to the resistance, \( R \). If the current is 280 milliamperes when the resistance is 5 ohms, find the current when the resistance is 20 ohms.

a. 1116 milliamperes  
   b. 70 milliamperes  
   c. 350 milliamperes  
   d. 1120 milliamperes

Objective 12: Graph Ordered Pairs

Use the following graph to answer questions 13 and 14.

13. What are the coordinates for the point identified by \( M \)?

a. \((1\frac{1}{2}, 5)\)  
   b. \(\left(\frac{1}{2}, 4\right)\)  
   c. \(\left(4, \frac{1}{2}\right)\)  
   d. \((5, 1\frac{1}{2})\)

14. From the given graph, state the identifier for the point \((0, 2)\).
Objective 13: Define Relations and Functions

15. Decide whether the relation defines a function: \{(-6,6), (-2,-2), (3,1), (3,5)\}
   a. Function  
   b. Not a function

Objective 13: Define Relations and Functions

16. Decide whether the relation defines a function: \(y^2 = 2x\)
   a. Function  
   b. Not a function

Objective 13: Define Relations and Functions

17. Use the vertical line test to determine whether or not the graph is a graph of a function

   ![Graph](image)

   a. Function  
   b. Not a function

Objective 13: Define Relations and Functions

18. Use the vertical line test to determine whether or not the graph is a graph of a function

   ![Graph](image)

   a. Function  
   b. Not a function

Objective 15: Solve Systems of Linear Equations with Two Unknowns

19. Solve the system of equations:
   \[
   \begin{align*}
   x + 6y &= -29 \\
   2x + 5y &= -30
   \end{align*}
   \]
Objective 16: Solve Application Problems Involving Linear Systems

20. Jimmy is a partner in an Internet-based coffee supplier. The company offers gourmet coffee beans for $12 per pound and regular coffee beans for $4 per pound. Jimmy is creating a medium-price product that will sell for $6 per pound. The first thing to go into the mixing bin was 14 pounds of gourmet beans. How many pounds of the less expensive regular beans should be added?

a. 41 pounds  
   b. 42 pounds  
   c. 43 pounds  
   d. 44 pounds

Objective 10: Solve Absolute Value Equation

21. Solve for $x$: $|4x - 2| = 6$

a. $\{2, -1\}$  
   b. $\left\{\frac{3}{2}, \frac{3}{2}\right\}$  
   c. $\left\{-\frac{5}{2}, \frac{3}{2}\right\}$  
   d. $\{-2, -1\}$

Objective 10: Solve Absolute Value Inequality

22. Solve the inequality: $|1 + 6d| + 4 < 7$

a. $(-\infty, 2) \cup \left(\frac{-5}{3}, \infty\right)$  
   b. $(-\infty, -\frac{2}{3}) \cup \left(\frac{1}{3}, \infty\right)$  
   c. $\left(-\frac{5}{3}, \frac{2}{3}\right)$  
   d. $\left(-\frac{2}{3}, \frac{1}{3}\right)$

Objective 14: Graph Linear Function

23. Graph: $5x = y - 4$

a. 

b.
Objective 17: Graph Conics: Parabolas

24. Graph \( f(x) = -4x^2 + 3x - 1 \)

Objective 17: Graph Conics: Circles
25. Graph \((x-2)^2 + (y+1)^2 = 16\)

a.

b.

c.

d.
APPENDIX F

SI Session Totals

The name of the students must remain confidential, so the students were assigned a number. The table below gives a tally of those who attended the SI sessions. This study only used the information from those students who attended at least 4 times, which equates to 80% of the SI sessions. The data of those who attended less than 4 sessions was not used in the final calculation.

<table>
<thead>
<tr>
<th>Student #</th>
<th>Number of SI Visits</th>
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<tbody>
<tr>
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<tr>
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APPENDIX G

Midterm Survey

Directions: Circle your answers

1. Did you visit the Academic Support Center?  
   Yes  No  
   If yes, how many times did you visit?  
   1  2  3  4  5  If more than 5 state the number of times: ______

2. Did you use a private tutor?  
   If yes, how many times did you visit?  
   1  2  3  4  5  If more than 5 state the number of times: ______

3. Did you visit your instructor’s office?  
   If yes, how many times did you visit?  
   1  2  3  4  5  If more than 5 state the number of times: ______

4. Did you attend the SI sessions on Wednesdays?  
   If yes, how many times did you visit?  
   1  2  3  4  5  If more than 5 state the number of times: ______

Results of the Midterm survey

<table>
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<tr>
<th></th>
<th>Non-SI Group</th>
<th>SI Group</th>
</tr>
</thead>
<tbody>
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<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1. Did you visit the Academic Support Center?</td>
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<td>15</td>
</tr>
<tr>
<td>2. Did you use a private tutor?</td>
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<tr>
<td>3. Did you visit your instructor's office?</td>
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<tr>
<td>4. Did you attend the SI sessions on Wednesdays?</td>
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</tr>
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</table>