A STUDY OF THE EFFECTIVENESS OF SUPPLEMENTAL INSTRUCTION ON DEVELOPMENTAL MATH STUDENTS IN HIGHER EDUCATION

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF EDUCATION

By

Jan Stephens, B.S., M.Ed.
Denton, Texas

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This quasi-experimental study examined the effects of participation in a Supplemental Instruction (SI) program on student test performance in a second-level developmental mathematics class in a four-year university setting.

Supplemental Instruction is an academic support program that integrates study techniques into course content. The program claims three primary benefits: 1) higher course grades, 2) higher semester grade point averages, and 3) greater rate of retention (Blanc, DeBuhr, & Martin, 1983). Kenney (1989) conducted further research which demonstrated that the methods used in SI were a factor in improvement rather than the additional time on task.

This research deviated from past research on Supplemental Instruction in that it examined effects of the program at the end of each test block rather than at the end of the course only. The quasi-experimental design was precipitated by an inability to control factors of participation and limited sample size. Test data were analyzed using analysis of variance; final course grades were analyzed using chi-square.

Results showed that the SI students scored higher on unit tests throughout the semester, and this difference in scores became significant as the semester progressed. The rate of D and F grades, as well as the number of course withdrawals, was lower for SI participants. Factors of gender, age, and degree of SI participation were examined. A significance was found between female non-participants and participants in the latter part of the semester; no

consistent difference was found in males. No significant difference was found when examining the effects of Supplemental Instruction in relation to factors of age or degree of participation in the program, but first-time students participating in SI showed significance over students who had previous course enrollment.

Results from the quasi-experimental situation had implications for future research and implementation. The effect of the SI leader as well as the instructor influence should be given further study.

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CHAPTER I

INTRODUCTION

College developmental mathematics programs have been steadily increasing over the last twenty-five years (Hall, 1985). To deal with the lack of preparation for college level mathematics, the State of Texas initiated the Texas Academic Skills Program (TASP) to determine the readiness of students entering higher education. On February 26, 1994, the Texas Academic Skills Program (TASP) Test was administered for the 37th time in accordance with Texas Education Code 51.306, HB 2182, 70th Legislature. In the area of mathematics, the score of 270, which is designated as the recommended minimum for enrollment in college algebra, was achieved by only 13.1% of the students. The remediation standard of 230 was attained by 55.2% of the students, and the base passing score of 220 was attained by 67.0% of the entering freshmen.

The problem of under-prepared students in the higher education setting has a long history. In 1994, higher education institutions are still dealing with the same dilemma. The problem takes on a more ominous note when the focus is narrowed to the prospects for success that developmental students can expect in college mathematics. In 1992, the university in this study tracked its developmental students to ascertain that only 13% successfully completed the first on-level college algebra class.

Remedial programs have been established to assist the under prepared students, but opinions as to their effectiveness are mixed. Proponents of remedial programs contend that until reform movements in public schools have had time to upgrade the level of exit abilities, college remedial programs are necessary. Some contend that adults who have been out of school for a

number of years need the opportunity to acquire the skill level necessary for success in college level courses (Platt, 1986). Landward and Hepworth (1984) advocate a support system for colleges with open-door admission policies. Opposition to remedial placement is found both in the students themselves and in legislative bodies (Mickler & Chapel, 1989). An argument against remedial programs points to the financial aspect of paying twice for students to learn basic skills; there is also the contention that colleges should not have to bring students to entry-level (Kozoil, 1989).

Initially, even though higher education was taking steps to provide assistance, students were not cooperating. Roueche and Snow (1977) reported that as many as 90% of all students advised and assigned to remedial courses never completed them. This caused many institutions to revise programs and require that students complete remedial courses before being allowed to enroll in on-level college courses.

Students still enter the higher education setting ill-prepared, and opinions are mixed as to what should be done to most effectively meet the needs of these students. No quick or easy solution to the problem exists, but innovative ideas continue to be explored. One approach that has gained recognition is Supplemental Instruction (SI).

Supplemental Instruction was developed in 1975 at the University of Missouri-Kansas City by Deanna C. Martin. It was created as as form of academic assistance for students enrolled in difficult health science professional schools. Because of its effectiveness in that setting, it was extended throughout the institution. In 1981, after a rigorous review process, Supplemental Instruction became one of the few post secondary programs to be designated by the U. S. Department of Education as an Exemplary Educational Program.

The goals of SI are threefold: 1) to improve student grades in targeted

courses, 2) to reduce the attrition rate in those courses, and 3) to increase the eventual graduation rates of students. Research that has been done regarding SI continues to verify the attainment of these goals, and they hold true across all disciplines (Martin, et al, 1983-a; Martin, et al, 1983-b; Pryor, 1989, Kenney, 1989; Martin & Arendale, 1991-a; UMKC, 1994).

Supplemental Instruction differs from traditional tutorial programs in that it integrates study skills for the particular course with content, thus creating an environment more conducive for retentive learning. SI focuses on historically difficult courses and puts the label of "high risk" on the course rather than on the students. This shift is intended to remove the stigma of a remedial program. Attendance is voluntary and open to any member of the targeted course.

Three key persons are involved in the SI program--the supervisor, a faculty member, and the SI leader. The supervisor is responsible for the identification and selection of a targeted course, enlisting faculty support, selection and training of leaders, and monitoring and evaluating the program. The faculty member of the targeted course is responsible for being a part of the leader selection, supporting the program through small class time allotments, and providing assistance to the leader if needed. This assistance may be in the form of consultation, resource materials, or suggestions. The faculty member also provides test grades for statistical analysis of program effectiveness.

The SI leader, who can make the program a success or a failure, is perhaps the most important member of the triad. The leaders are usually students who have taken the course from the cooperating instructor (although this is not required), proven their competence in the course, and received training in the SI model. The leaders attend course lectures, take notes, read all assigned materials, and conduct three to five out-of-class study sessions

each week. The leader is a model student and a facilitator who helps other students integrate content with learning strategies. Skills which allow leaders to be out-going and relate to others quickly and effectively are definite assets.

Traditionally SI programs are implemented in courses such as algebra, chemistry, biology, and other "high-risk" courses. The designation of "high-risk" is assigned to courses with at least a 30% documented rate of DFWs (D and F refer to final course grade, and W denotes withdrawal from the course). Developmental classes have not been included in this category because students do not usually have the option of dropping them. In addition, studies done and reported by the University of Missouri at Kansas City state that students did not consider remedial classes as high-risk. Dissertations published to date addressing the topic of Supplemental Instruction in mathematics have focused on higher level courses such as algebra or calculus; none has addressed the situation of the remedial class (UMKC, 1992). An inquiry was made through the SI international newsletter as to whether other individuals or institutions were at present conducting studies in the area of developmental mathematics. None have been documented to date.

Statement of the Problem

The problem of this study was to examine the method of Supplemental Instruction in increasing the level of mathematics achievement in a developmental mathematics class in a higher education setting.

Purpose of the Study

The purpose of this study was to determine whether participation of developmental mathematics students in a Supplemental Instruction program would yield a statistically significant difference in course achievement. This difference was examined through unit and final test grades, the degree of participation by various gender and age groups, and the percentage of course completion recorded by participants and non-participants.

Research Hypotheses

1) Students who participate in the Supplemental Instruction program will score significantly higher on each of six course tests and on the final course grade than students who do not.

2) Students engaging in a high degree of participation in the Supplemental Instruction program will score significantly higher on each of six tests than students who engage in a low degree of participation.

3) A significantly higher participation rate in the Supplemental Instruction program will be found among non-traditional (age twenty-three and over) students than among traditional-age (under twenty-three) students.

4) A significantly higher course completion rate will be found among students who are participants in the Supplemental Instruction program than among students who are not.

Significance of the Study

No studies have examined the implementation of the Supplemental Instruction program with developmental students in higher education. Mathematics is the area with the lowest pass rate among the three areas tested as evidenced by results from the 37th administration, in February 1994, of the Texas Academic Skills Program (TASP) Test. Reports showed that 33% of the students did not make the passing score of 220, and 86.9% failed to attain a score of 270 which is the recommended minimum for enrollment in the first on-level college algebra class. Steps need to be taken to assist students in attaining skills necessary for their success.

This study is significant in that it was designed to:

1. Determine whether Supplemental Instruction was an effective program for improving achievement in developmental mathematics.

2. Investigate whether effectiveness, if found, was restricted to any particular age or gender group.

3. Investigate whether the level of participation in Supplemental Instruction was a factor in effectiveness.

4. Investigate whether participation in Supplemental Instruction was a factor in increased course retention.

Method of Procedure

A quasi-experimental study was conducted to examine the effects of the Supplemental Instruction program on students in a developmental mathematics class. The research design followed Campbell and Stanley's Nonequivalent Control Group Model (1963) with repeated measures.

A single developmental math class was selected at random from the seven that were offered in the spring semester. The design of a single class and one leader was constructed due to two considerations: no instructor had multiple sections, and there would be a built-in control for instructor and leader effect.

Participation was open to all and voluntary. The students who chose to participate in the Supplemental Instruction program constituted the experimental group; the non-participants constituted the control group. It was recognized that since this was a self-selection situation, true experimental conditions did not exist.

Determination of the extent of equivalent groups was conducted through examination of student data. These data consisted of high school class rank, age, gender, and ethnic factors.

The study consisted of quantitative analyses comparing the unit test grades of students who participated in the Supplemental Instruction (SI) program with those who did not. This comparison of grades was made after each test. This did not follow the SI model, which looks at the final course grade, but it was believed that through examination of unit test grades a more powerful study could be done. The examination of unit test and final exam

grades through analysis of variance, and the examination of course grade with chi square was employed to test for significance in the first hypothesis.

Attendance records kept in the SI study sessions were combined with test results to determine significance in attendance levels in the second hypothesis. The attendance records combined with school demographic data documenting student age were used to determine significant between age groupings in the third hypothesis.

End of course information regarding withdrawals was used in a chi square analysis to test for significance in hypothesis 4. Significance for all tests was set at the .05 level.

A descriptive report is included to document events and patterns which took place during the time of the study that did not lend themselves to statistical analysis.

Records of traditional tutorial assistance gained through the mathematics assistance clinic and student-secured private tutoring were kept to the degree that was possible. Sign-in sheets documented attendance in the math clinic, and private tutors were requested to submit monthly records of tutorial time. Although this information was not used in the statistical analysis, it is noted in a descriptive analysis.

This program took place during the spring semester of 1994 for a period of approximately 15 weeks beginning on January 13, 1994 and concluding on May 3, 1994. Following the traditional Supplemental Instruction model, students were strongly encouraged, but not required, to attend the scheduled sessions. The researcher was a participant observer and program supervisor.

The Supplemental Instruction model program offers a minimum of three (3) fifty-minute study sessions each week. The program under study initially conducted five (5) sixty-minute sessions and added two (2) sixty-minute sessions after three weeks due to student demand. In these sessions

students participated in a variety of formats, working course concepts in an interactive mode rather than in a passive, receptive situation. Activities that were used in the sessions are outlined in the descriptive analysis of the program.

Definitions

Supplemental Instruction is the program created in 1975 by Deanna Martin at the University of Missouri-Kansas City in which student leaders become facilitators integrating content with process to create a more significant learning experience.

Delimitations of the Study

The following delimitations are included as a part of this study:

1) This study was restricted to a single developmental mathematics class at a small, agricultural four-year university.

2) This study was conducted over the period of a single semester during the 1993-1994 school term.

3) The small sample size and the selection of an intact class limits claims of generalizability to large populations.

Basic Assumption

The Supplemental Instruction program has been shown to be effective in research to date because of the program design and not because of the additional time on task (Kenney, 1989).

Treatment of Data

Since this was a quasi-experimental study, due to the inability to control certain factors and the sample size, a statistical analysis was combined with a descriptive report of findings and implications. A statistical analysis was performed using analysis of variance for unit tests and chi square for final course grade and rate of course completion. Significance was set at the .05 level. Findings were reported on the significance of Supplemental Instruction

relating to test grade average for participants and non-participants, for traditional and non-traditional students, and for high-level and low level participants. These analyses were performed on each of the six testing blocks.

CHAPTER II

REVIEW OF LITERATURE

The percentage of students needing assistance in order to be successful in the higher education setting has not changed significantly in over a hundred years (Maxwell, 1979; Lederman, Ribaudo, & Tyzewic, 1985; Grable, 1988; Koch, 1992). The University of Michigan addressed this issue in 1852. In 1862 Iowa State College created a remedial program for students with deficiencies in mathematics, reading, and writing. Harvard, Yale, Princeton, and Columbia Universities addressed the same situation around the turn of the century, because entering students could not perform at the basic level required by institutional admission standards (Maxwell, 1979). A 1983 national survey of college instructors found that 85% of the respondents rated incoming freshmen as poorly prepared. The largest area of deficiency, 32%, was reported in mathematics. At the same time over 60% of the four-year and 80% of the two-year colleges in the United States offered remedial courses (Lederman, Ribaudo, & Ryzewic, 1985). A study of 62 two-year colleges identified 75% or more as needing remedial math courses (Grable, 1988). In the fall of 1987, slightly over 792,000 students enrolled in Texas institutions of higher education. Estimates state that approximately 40% of these students did not have skills sufficient for success in college in the areas of reading and witing, and over 50% were diagnosed as having deficiencies in the area of mathematics (Koch, 1992).

Mismatch of Teaching and Learning Strategies in Higher Education

A large number of students enter the higher education setting without a sufficient knowledge of basic mathematical concepts to be successful in

college-level mathematics courses (Koch, 1992). The problem of how best to help these students with academic difficulties falls on higher education. This dilemma of assistance lies both in the structure of the higher education setting and in the nature of students themselves. There may be an incongruence in the match of a student's developmental readiness with the structure of the new setting. In elementary and secondary education, research based practices such as cooperative learning or pair problem solving in which students are actively involved are often abandoned in the higher education setting; students have less opportunity to do practice activities in class (McDonald, 1986; Koch, 1992). Some students do not outgrow the need for concrete operational learning. Lawson and Renner (1975) found that over 50% of students entering higher education are operating at this level. College professors may deliver information in a lecture format; mathematics problem solving is done primarily by the instructor thus allowing students to be passive learners. Higher education is resistant to changing its methods lest its traditional academic freedom be challenged; the larger the university, the more difficult implementation of change becomes (Smilkstein, 1993). Educational institutions alone, however, are not to blame for the situation of the under prepared student.

Research indicates that a large majority of developmental students have study habits which result in a variety of academic problems. For them, mathematics consists of three elements: 1) following teacher-made rules, 2) recalling and applying rules and facts, and 3) getting recognition for a correct response (Lampert, 1988). Students who believe that learning requires memorization either of facts or process tend to be passive learners and unsuccessful problem solvers. They have not developed active learning strategies (Lochhead, 1985). They learn quickly to remain silent in the higher education mathematics class (Koch, 1989). They tend to attribute poor academic performance to luck, fate, or powerful others (Glasser, 1981). In the

area of mathematics, difficulties may be attributed to the inability to formulate a precise descriptive definition of verbal abstractions, although students can memorize another's definition and reproduce what they have memorized. They have trouble applying formal intellectual processes to verbal symbols and abstract ideas (Bell, 1978). Brown and Burton (1978) stated that the unsuccessful math student has built twelve (12) years of misconceptions and systematic, consistent errors. Because of this, traditional methods are neither successful nor appropriate at the college level. Metacognition needs to be a component of mathematics instruction (NCTM, 1989).

The National Council of Teachers of Mathematics, in its professional standards, advocates that the current trends in mathematics education affirm that students must not assume a passive role, but rather they must be active participants in learning. The Council maintains that creating powerful learners implies the creation of an environment that is usually different from that practiced in the traditional mathematics classroom (NCTM, 1991). Other elements may also affect performance. As a rule, students are not adept in notetaking or text reading, and the skill is not generally a focus of the curriculum; therefore, students who have experienced math difficulty in the past continue to have difficulty in higher education. They do not automatically become skilled, independent mathematics learners when they leave public school (McDonald, 1988; Novak, 1983; Proga, 1987; Garfield, 1988).

Higher Education Efforts in Remediation

In an attempt to provide assistance, an increasing number of colleges and universities are offering study skills classes or tutorial programs. Study skills classes, which are usually offered to freshmen, attempt to orient students to higher education practices as well as methods of studying. Study skills classes provide varying degrees of benefits, depending upon the particular curriculum and emphasis of a particular program. In a study conducted at Southwest Virginia Community College in 1993, Waycaster found that the

regular study skills courses were deficient in practical applications; this was particularly true in the area of mathematics. Little information is traditionally presented on adapting study techniques for math, and content is seldom used in juxtaposition with the skills being taught. The generic approach that is used does not allow for differences in methods. Reading, for example, is not practiced in the same way for all classes. History and mathematics utilize opposite approaches of condensing versus expanding. Students were tracked to evaluate success after completing a study skills course which incorporated a math section. A 50% pass rate was documented for students who enrolled concurrently in a math class; this contrasts with a 30% pass rate for those who enrolled in a math class the following semester. This study led to the recommendation that study skills be taught simultaneously with content for maximum learning to be achieved.

The option most often chosen by students seeking help is that of tutorial assistance. It may utilize either an individual or group format (MacDonald, 1993). The effectiveness of this option is well researched. Tutoring can improve students' grades, reenrollment rates, and satisfaction with school, but it can also be subject to a wide range of variability and is offered without guarantee (Bloom, 1984; Cohen, Kulik, & Kulik, 1982; Devin-Sheehan, Feldman, & Allen, 1976; Maxwell, 1991; Rosenshine & Furst, 1969).

When tutoring is utilized in a one-on-one format, mathematics tutors frequently reteach the lesson in much the same manner as the instructor. They tend to give answers or work problems for students thus depriving them of developing their own problem-solving skills (Smilkstein, 1993). While this might provide some immediate need, tutoring may provide little long-range help to developmental students.

Group tutoring can either duplicate the disadvantages of individual assistance or it can prove a benefit to students primarily through the opportunity for group interaction. Uri Triesman found a strong correlation

between success in mathematics and students studying in groups (Garland, 1993). Other studies confirmed that engaging in small group problem solving situations increases students' metacognitive awareness (Long & Long, 1987; Schoenfeld, 1985, 1987). The practice of pair problem solving raises awareness of thinking processes, allows the interaction that students need and promotes independence (Lochhead, 1982, 1985; Whimbey & Lochhead, 1982, 1986; Campione, Brown, & Connelf, 1988; MacDonald, 1993).

The failure or success of the tutoring experience depends primarily on the tutor. The strongest correlate of developmental education students' success was a combined factor of tutoring and tutor training. For tutoring to make a difference, tutor training is a critical element (MacDonald, 1993). Too often, tutoring programs do not provide adequate and consistent tutor training, and the result is a focus on getting the correct answer only and not on the process being used.

Higher education would be best served if it received students from the public schools who were not deficient in their level of readiness. Public education is in the process of restructuring itself through a variety of programs that are intended to up-grade the level of student achievement. That process may very well decrease the percentage of students needing remedial assistance at the college level, but a need for help still exists for the returning adult who seeks skills for a new career or the marginal, unmotivated high school graduate who now seeks success in higher education (Mickler & Chapel, 1989). For these students and others who periodically need to learn in more effective ways, there must be opportunities for learning. The methods used have not been sufficient to significantly decrease the problem. Perhaps it is time to look at the learning process to determine where a breakdown could be occurring.

The question to be answered is how can students more effectively be helped. Many solutions are offered (Martin, 1980; Garfield & McHugh, 1978;

Resnick, 1981; Sartain, et al, 1982; Harri-Augstein, Smith, & Thomas, 1982; Weinstein & Rogers, 1984; Pressley, 1986; Thomas & Rohwer, 1986; Zimmerman, 1986; King, Stahl, & Brozo, 1984; Nist & Hynd, 1985; Mallery & Bullock, 1985). Most concentrate on the manner in which content is presented in the classroom and address topics such as teaching style, questioning techniques, and methods of assessment.

Cognitive psychology provides some insights into the learning process. Metacognition is the awareness of one's cognitive processes (Flavell, 1976). Costa (1984) adds that it includes the ability to plan and organize the steps and strategies of problem solving and evaluation of those procedures. Metacognition in the area of mathematics involves active learning that aids students to be aware of, reflect upon, and consciously direct thinking and problem-solving efforts. Piaget (1968, 1970) and other developmentalists believe that the cognitive system operates one way when an individual is young and in a more complex, abstract way when the individual is older. New research suggests that the cognitive system itself does not change. Some students do not outgrow a style of learning, but rather they continue to need a type of instruction that is often abandoned in higher education. Lawson and Renner (1975) stated that more than 50% of all college freshmen are still at the concrete operational level of thought. For these students, mathematics involves only calculations; they are not actively involved in the development of their own mathematical knowledge (Koch, 1992). Lampert (1988) states that students may be able to follow the teacher's rules and arrive at a sanctioned correct response without understanding having taken place.

Polya (1957) described three steps necessary for understanding a problem: devising a play of action, activating the plan, and evaluating the process. Mathematics educators contend that many students cannot effectively monitor their own problem-solving procedures (Campione, Brown, & Connell, 1988; Garofalo & Lester, 1985; Lochhead, 1985). This poses a problem since

Schoenfeld (1987) found that the self-monitoring process contributes to successful problem solving.

Another explanation for poor performance by students is the "cognitive Doppler effect" described by Kozoil (1989). Because of the time delay between classroom observation and practice at solving problems, the "drop in cognitive performance as students pass from the classroom to the out-of-class environment" (p. 14) tends to exert its effect on learning. Students also frequently do not experience the practice in problem solving that is required for mastery of concepts, and when they do admit to needing help there are limited options available.

Koch (1992) claims the implementation of a contructivist approach would assist these students in three ways: by decreasing the math anxiety that many students have from experiencing twelve years of failure in mathematics, by developing a positive attitude towards mathematics, and by helping students acquire a greater math proficiency than with a lecture approach. Since the numbers enrolled in developmental classes are not showing promise of a sudden decline, additional ways of assisting these students need to be examined.

A common element of other assistance options is the factor of either content or process being taught in isolation. Some educational researchers contend that the two must be integrated in order to be maximally effective (Dimon, 1988; Keimig, 1983; Simpson, 1993). Keimig developed a "Hierarchy of Learning Improvement Programs". Lowest on the ranking were remedial courses that taught skills in isolation; the second lowest was tutoring, since it generally was used after academic difficulty or failure had been experienced. Programs that integrated content and process were ranked near the top of the effectiveness scale.

Higher education would assist its students who need an extra measure of assistance by designing a program that integrates the process and content,

makes learning an active venture, and echoes the beliefs that effective learning has taken place when an individual can retain information and become the source of that same information. Such a program was designed in 1975 that incorporates these elements; it has come to be known as Supplemental Instruction.

The Supplemental Instruction Option

Supplemental Instruction (SI) was developed at the University of Missouri-Kansas City. In 1981, after a rigorous review process, it became one of the few post secondary programs to be designated by the U.S. Department of Education as an Exemplary Educational Program. Supplemental Instruction integrates content with study skills and replaces the concept of a "tutor" with that of a "leader" who facilitates the learning experience rather than becoming a peer teacher who simply reteaches or gives answers. The goal is to provide academic assistance to students by helping them to master course content while at the same time developing and integrating effective learning and study strategies. The research to date documents that students who participate in this program show a .50 higher mean grade point average in the specific course than those who do not. This tends to hold true across all disciplines (Martin, et al, 1982; Martin, et al, 1983; Pryor, 1989; Kenney, 1989; Martin & Arendale, 1991).

The program makes three claims that have been supported across the disciplines in research that has been done. The first claim is that students participating in SI within targeted courses earn higher mean final course grades than students who do not participate in SI. The second claim is that students participating in SI succeed at a higher rate (withdraw at a lower rate) than those who do not participate in SI. The third claim is that students participating in SI persist at the institution at higher rates than students who do not participate in SI (UMKC, 1994). Research that has been done regarding SI continues to verify these claims.

In a landmark study on the effectiveness of Supplemental Instruction in mathematics, Kenney (1989) used two intact college calculus courses to examine the issue of whether or not the extra time on task made the difference in achievement. Each class was divided into three statistically equivalent discussion sections: one group received assistance in the Supplemental Instruction model, the second group received assistance in the traditional tutorial, content-based discussion-only assistance of a graduate teaching assistant, and the third group in each class did not participate in the study. One class met in the morning; the other met in the afternoon. Using a variety of statistical methods, Kenney found that students in the SI groups earned significantly higher final course grades than the students in the other groups. In a follow-up study the following semester which tracked the students in the original studies, no significant difference was found between their final course grades when Supplemental Instruction was not an option. Kenney's studies are unique in that they examined the effects of Supplemental Instruction in a mathematics course, used a graduate student as an SI leader, and used regularly scheduled adjunct times for meetings. Students were required to meet for one type of assistance as a part of the class requirement. The factor of time alone did not account for the increase in achievement.

Supplemental Instruction and Brain Theory

In order to better appreciate the benefits that Supplemental Instruction can offer to developmental students, one might first consider a learning theory concerning brain changes that occur during learning. The theory of neuroplasticity advocates a physiological basis for learning (Fishbach, 1992; Jacobs, Schall, & Schieibel, 1993; Kandel & Hawkins, 1992; Milgram, MacLeod & Petit, 1987; Shatz, 1992). In contradiction to traditional beliefs that the life's supply of dendrites, the branching fibers of neurons, or brain nerve cells, are in place by age two, the new theory claims that they grow throughout life in direct relation to both the amount of non rote processing an individual does as

well as the degree of intellectual stimulation of that practice (Hill et al, 1993; Jacobs et al, 1993; Katzman, 1993). The increase of processing assures a greater number and density of dendrites that contribute to more complex, refined, and high levels of understanding. At-risk students may very well be dendrite-poor and in need of interactions if they are to be successful. They require time and opportunity to construct a firm learning foundation. Research suggests that students must integrate new information with previous learning and experiences (Mooney, 1993). New or higher level dendrites/knowledge can grow only from existing dendrites/knowledge. Students who have not built the network needed to be successful in higher education may not have had previous experiences. When students create their own images, they are connecting learning to their own experiential backgrounds and establishing their own way of thinking (Simpson & Dwyer, 1991). Meaning must be connected to one's experiences if it is to be anchored (McCarville, 1993). Smilkstein (1993) believed that content knowledge of algebra concepts with related procedural knowledge of problem-solving strategies are acquired through interactive processing. Either process alone would impede mathematical success.

Learning occurs with the thoughtful and active processing of experience through increasingly refining levels of activity. This explains the physiological difference between a simple low level of understanding and a complex, abstract, high level of understanding. The difference is the underlying brain structure growth. Learners must grow their own dendrites; no one can do this for them. Telling, showing, or demonstrating will not cause it to happen. Their listening, watching, and reading may not provide the growth that is needed for understanding. Students need opportunities to engage in increasingly refined states of active learning and thoughtful processing of experience (Von Glasersfeld, 1983; Smilkstein, 1993). If this theory is accepted, then there can be an understanding of the breakdown of

mathematical algorithms in the higher education setting. Passive learners, who only performed required tasks, have never built the network that is now required for the new setting. Piaget believed that an individual moves from the concrete operational to the formal operational state (abstract thought) through the use of language. Elaboration serves to help an individual internalize concepts. Bauersfeld (1980) stated that mathematics is learned through human interaction. Supplemental Instruction offers the opportunity for students to interact in non-threatening group settings and explore not only the "what" of material but the "why" and "how" as well.

The lack of sufficient structure is not the only aspect of the neuroplasticity theory. The building of the dendrite network can be fostered or inhibited by other factors. Negative feelings of fear and anxiety inhibit the synaptic connections as well as thought and memory. Hormones produced by positive emotions such as confidence and curiosity facilitate synaptic connections and facilitate thinking and remembering (Smilkstein, 1993). There is also a hormonal effect created by self-doubt, anxiety, and fear of failure. These emotions are in evidence in developmental students in the college setting. Koch (1989) found that 92% of the developmental college students surveyed could relate vivid memories of being embarrassed by a teacher in a mathematics class during their precollege schooling. They have developed negative attitudes, experienced repeated failures, and have little hope that things will change.

Summary

Among the many problems faced by teachers and administrators in higher education, remedial programs and developmental students is a large one. Society demands entry for students, even those who are underprepared. At the same time resources to provide a first-quality range of college offerings strain the financial base. Developmental students have come with the hope of not repeating the frustrations of the past; they have come with a readiness to

start anew. The literature suggests a variety of options for academic assistance, but no single technique provides the ultimate solution. If Supplemental Instruction does in fact create a more effective learning situation, where is that opportunity more needed than in the remedial setting? The human factor both in giving and receiving assistance is extremely variable. Through a combination of techniques involving multi-sensory approaches to accommodate learner differences and through a structured training of helpers, the most significant improvement in student achievement is seen. Supplemental Instruction meets these requirements and offers a new option in assistance.

CHAPTER III

RESEARCH DESIGN

Setting

This research took place in a university located in North Central Texas. Its enrollment of approximately 6300 comes primarily from surrounding small agricultural communities. The university recently stepped up efforts aimed at increasing retention. Among the programs chosen for implementation as a part of this effort was Supplemental Instruction (SI) because of its record of increased retention in high-risk courses (UMKC, 1994). Slightly over 50% of the university's enrolling students each term had failed to pass the Texas Academic Skills Program (TASP) Test or make an equivalent score on a pre-TASP placement test and as a result were classified as "developmental" by the University. The percentage of developmental students falling into this category because of a mathematics deficiency ranged from approximately 60%-85%. For that reason, the area of mathematics was targeted as one of the content areas to receive SI assistance. Research studies on Supplemental Instruction exist in higher level math classes such as college algebra and calculus, but because of the greater number of students who could potentially be served in the developmental setting, and because a lack of research studies existed in that area, a decision was made to implement the program in a developmental math class on this campus.

Two levels of developmental mathematics are offered to students who have either failed the math section of the TASP test, scored low on an entry-level placement test, or chosen to update their math skills after an extended absence from the educational setting. The first level course began with the study of signed numbers, included linear equations and inequalities, absolute

value, scientific notation, and ended with polynomial operations and factoring. The second level course briefly reviewed factoring of polynomials and moved on to the topics of rational expressions and equations, ratio and proportion, variation, fractions involving polynomials, complex fractions, linear equations and graphs, irrational and imaginary numbers, and ended with quadratic equations and graphing of parabolas. After successful completion of the two courses, it was assumed that students could be academically successful in college algebra.

Subjects

The subjects of this study were students enrolled in a second level developmental mathematics class. The intact class was selected by the administration for this study because of its size. With an initial enrollment of 107, it was the largest of the seven sections offered during the semester under study. Each section was taught by a different instructor. While the decision to select only one class was made because of financial constraints, it was conducive to this study in that it provided a control for instructor and leader effect.

The instructor of the chosen class was provided with information concerning the Supplemental Instruction program and asked to participate; consent was granted. Participants were aware that they were part of a new program, Supplemental Instruction, but they were not aware that they were a part of this research study. The researcher's role in this study was that of program supervisor and participant/observer.

Research Design

The purpose of this study was to examine the effects of Supplemental Instruction on mathematics achievement in a developmental class. The traditional pattern of reporting statistical significance focused primarily on final course grade and retention rates. As a result, students who were not enrolled at the end of the semester were lost in the data analyses. It was the

intent of this researcher to derive a clearer picture of the effects of SI by employing an alternative reporting method through the examination of test scores after each testing block and to conduct a statistical analysis with various moderating variables. This study was designed to provide an independent snapshot at intervals throughout the semester and to examine those for statistical significance.

The course grade, as outlined in the selected class syllabus, was determined by replacing the lowest of the five unit test grades with a homework/lab grade and averaging the five grades to obtain a number which represented a 2/3 weight. The final exam constituted the other 1/3. The design of this study focused on an examination of each of the unit tests as well as the final exam in order to ascertain whether there was a significant difference between students who chose to participate in the Supplemental Instruction program and those who did not. Each unit test was subjected to an analysis of variance with moderating variables of gender, age, degree of participation, and course history. The final course grade, which was composed of test data, non-test data, and possibly the deletion of test data, was examined along with course withdrawals using a chi-square analysis.

Interview notes combined with notes on classroom behavior patterns and SI study session behaviors added to the ethnographic aspect of the study. It was believed that the combination of qualitative and quantitative measures might provide a more complete picture due to the particular limitations of the study than one aspect alone.

Due to the inability to obtain a true control and experimental group, attempts were made to determine group equivalency. Statistical procedures using chi square established group equivalence utilizing the factors of age, gender, and high school rank; the factors of ACT/SAT test scores could not be used due to the fact that approximately 25% of the students had been admitted to the university without this information. The absence of a significant

number of minority students in this setting also eliminated examination of the ethnic factor.

Program Implementation

Recruitment of leaders for the University's Supplemental Instruction program was conducted, and training followed. The SI training followed the model provided by the University of Missouri-Kansas City. It focused on study skills for the specific courses being served and consisted of a variety of topics including memory techniques, text reading, and examination of and practice in various notetaking formats.

One facet of the training module that was particularly stressed was the aspect of redirecting student questions in order to avoid giving answers. Observation of traditional tutorial settings and conversations with leaders at other institutions who had implemented SI in higher math courses disclosed that learner initiative was a common weakness. The supervisor repeatedly pointed out that leaders must work on directing students to search notes or think when seeking answers. Although question redirection was only one exercise of the training module, this was stressed as a most important aspect in the area of mathematics.

A final training segment focused on designing study sessions for the particular discipline and topic. Leaders practiced hypothetical situations and were encouraged to provide a variety of activities in which students could participate.

During the first class meeting, the students in the selected class were given details of the Supplemental Instruction program by the program supervisor-researcher. The emphasis was made that the program was not remedial in nature but was available to anyone seeking to improve or reinforce skills, and that the program had demonstrated an improvement in test grades and overall course grade point average in participants. Also at this time, the supervisor distributed a survey that asked for two items of

information which would be used to determine session times. The first was an assessment of the degree of interest in attending the program. Students were asked to select their level of interest on a scale of 1 (not interested) to 5 (very interested). They were invited to mark, on a chart with hour time blocks from 7 a.m. to 10 p.m. Monday through Sunday, the times when they would be able to attend study sessions. The blocks with the greatest concentration of interest would be designated as study session times.

After the surveys were collected, they were sorted in groups of low (1-2), medium (3), and high interest (4-5). Session times were determined from information supplied by the high-level interest group. An examination of medium interest surveys revealed that the times set coincided with a strong majority in this level as well. Since the University did have a mathematics clinic open from 2:30 - 4:30 p.m. and 6:00 - 9:00 p.m., and this was available to students, it was decided that the SI sessions would be conducted during the morning hours between 9:00 - 11:00 a.m. on Mondays, Wednesdays, and Fridays. While this exceeded the traditionally recommended number of three to five, fifty-minute sessions prescribed by the model SI program, an examination of the surveys revealed that a significant number of students had either a 9 a.m. or a 10 a.m. class and were not on campus in the afternoons. For that reason, it was determined that the extended offering would better meet the needs of all students who wished to participate. Attendance in the morning sessions was initially small but increased steadily throughout the semester.

After three weeks, the request by students to extend the SI sessions to include an afternoon time was granted. The afternoon had originally been shunned for SI sessions because of the existence of the math clinic, but because the tutors in the clinic setting were dealing with students in a variety of courses, the developmental students felt that they could receive better assistance in a setting structured exclusively for their particular course and dealt with their professor's methods. Comments from the students expressed

their desire to receive more assistance than "answers only". From the date that the 3:00 p.m. Monday and Wednesday sessions were added, attendance was good and remained constant. It did not experience the small and growing scenario that had been the pattern in the morning sessions.

Records were kept regarding each student's SI session attendance, the number of visits to the university's math clinic, and a record of self-secured tutorial assistance. After the administration of each of five unit tests, as well as the final exam, statistics were examined comparing the test grade with participation or non-participation in SI and with moderator variables of age, gender, session attendance, and course frequency. An analysis of variance was used to determine statistical significance between groups on unit tests. Chi-square was used to determine statistical significance in final course grade.

Hypothesis #1

The examination of unit test and final exam grades provided the basis for determining if a statistical significance in academic achievement existed between participants and non-participants.

Hypothesis #2

The documentation of SI session attendance and test grades provided the basis for determining if a statistical significance in academic achievement existed between students engaged in low, medium, and high attendance.

Hypothesis #3

The accurate documentation of SI session attendance and school records verifying the age factor were used to determine if a statistical significance in the participation rate between non-traditional age and traditional age participants.

Hypothesis #4

The accurate documentation relating to course withdrawal was used to determine if a statistical significance existed between SI participants and non-participants.

Although data were collected to test for the four hypotheses presented, a wide range of data were collected to determine if other patterns could be discovered in the study.

CHAPTER IV

PRESENTATION OF DATA

Introduction

The purpose of this study was to compare the effects of Supplemental Instruction (SI) upon participant and non-participants groups in a developmental mathematics class in higher education. The study examined, in a broad sense, the difference between test scores of the two groups. It was realized, however, that there was a possibility that no significant difference might be demonstrated in the overall groupings while statistically significant differences could exist in subgroups. For that reason, the participant and non-participant groups were sub-divided by factors of gender, age, and course repetition. This data were reported with respect to the first hypothesis. The null hypothesis, $\mu_0 = \mu_1 = \mu_2$, that there is no difference between SI participant and non-participant groups on test scores, was examined using analysis of variance. Since the Supplemental Instruction program examines final course grade for the two groups, that variable was also examined. A chi-square analysis was used because of the non-numeric nature of the grade as well as the method of grade determination. Failure to show statistical significance at the .05 level on at leasts three of the six course tests and the final course grade would result in retention of the null hypothesis.

The second hypothesis examined the significance of the level of participation in the Supplemental Instruction program. The null hypothesis, $\mu_0 = \mu_1 = \mu_2 = \mu_3$, that there is no difference between low, medium, and high degree of participation, was examined using analysis of variance. Failure to show statistical significance at the .05 level on at least three of the six course

tests would provide cause for rejection of the research hypothesis and retention of the null hypothesis.

The third hypothesis examined the composition of participant groups with respect to age. The null hypothesis, $\mu_0 = \mu_1 = \mu_2$, was that no difference exists in degree of participation by traditional (under age 23) students and non-traditional (age 23 and over) students. A higher rate of participation in three of the test blocks was required for rejection of the null hypothesis.

The fourth hypothesis focused on the area of course completion in the participant and non-participant groups. The rate of completion of participants was compared with the rate of completion of non-participants in light of the null hypothesis, $\mu_0 = \mu_1 = \mu_2$, that no difference existed between the two groups. Statistical significance at the .05 level was required for rejection of the null hypothesis.

Demographics of Group

The establishment of true group equivalence in the experimental (participant) and control (non-participant) groups was not possible due to a limitation of factors. Scores on ACT/SAT tests were available for only 72% of the students enrolled in the class. Others had been admitted without this information due to exempted status. The factor of ethnicity was not used due to the limited number of minority students enrolled. The structure of the groupings did change during the course of the semester.

Table 1.

Initial Class Composition

High School Class Rank	Total Class	Participants	Non-Participants
1st quartile	12.9% (*n* =14)	2.8% (*n* = 3)	10.1% (*n* =11)
2nd quartile	44.0% (*n* =47)	9.2% (*n* =10)	34.8% (*n* =37)
3rd quartile	31.2% (*n* =33)	5.5% (*n* = 6)	25.7% (*n* =27)
4th quartile	11.9% (*n* =13)	2.7% (*n* = 3)	9.2% (*n* =10)

(table continues)

	Total Class	Participants	Non-Participants
Gender			
Male	58.9% (*n* =63)	10.3% (*n* =11)	48.6% (*n* =52)
Female	41.1% (*n* =44)	8.4% (*n* = 9)	32.7% (*n* =35)
Age			
Traditional	79.5% (*n* =85)	10.3% (*n* =11)	69.2% (*n* =74)
Non-Traditional	20.5% (*n* =22)	8.4% (*n* = 9)	12.1% (*n* =13)

The composition of the class prior to the first test was examined from the aspect of course-repeaters.

Table 2.

Class Demographics with Respect to Course Repetition

	0 times	1 time	2 times	3 times
Previous course enrollment	57.7%	35.6%	5.6%	1.1%

Additional information on the group revealed that 56.2% did not take the first level developmental class, 38.2% took the first level and passed the first time, and 5.6% took the first level class and passed the second time. No students who were enrolled in the class during this study had passed course requirements on the third or subsequent attempts.

In order to appreciate the sample under study, the composition of the groups was examined at each test block with relation to the factors of gender and age. In relation to the gender factor, the class composition was initially male-dominant and did not change during the course of the semester although there was some slight variation in percentages within the test blocks.

Table 3.

Overall Composition of Class by Gender

	Test #1	Test #2	Test #3	Test #4	Test #5
Male	58.9%	59.1%	58.6%	58.3%	54.8%
Female	41.1%	40.9%	41.4%	41.7%	45.2%

When the class composition was examined with respect to age, the percentages

of traditional age (under age 23) and non-traditional age (23 and over) revealed a different pattern. The percentage of traditional student participants increased, and the percentage of non-traditional student participants decreased.

Table 4.

Composition of Class by Age with Respect to Test Blocks

	Test #1	Test #2	Test #3	Test #4	Test #5
Traditional	79.5%	81.9%	84.0%	84.5%	85.5%
Non-Traditional	20.5%	18.1%	16.0%	15.5%	14.5%

Presentation of Quantitative Data

Hypothesis #1

The hypothesis was tested through examination of test scores from each of the six tests administered during the course of the semester. It was believed that this type of analysis would prove a more powerful test of the statistical significance than overall course average alone.

The first test given in the class was termed a "pull-back" test. Any student not scoring 60 would be automatically pulled back to a first-level developmental class. Exceptions to this rule were granted on an individual basis after a student conferenced with the instructor and presented a plan of secured assistance. The belief was that any student who was willing to make this extra effort might be successful.

Twenty-nine of the 107 students tested scored below 60. Of the 20 students who had participated in the SI program prior to the first test, three students (15%) scored below 60 and were pulled back. This compares with twenty-six students (29.9%) in the non-participant group of 87. The three pull-back participants were non-traditional students with work and family obligations and returning to school after an extended absence from the education setting who had expressed a need for assistance in order to be successful in the class. No significant difference was indicated between the SI

participants' and non-participants' average on the first test. The average for the SI participants was 67.80 (n =20); the average for the non-participants was 66.31 (n =87).

Table 5.

Comparison of Participant and Non-Participant Groups on Unit 1 Test

Source	*Sum of Sqr.*	*DF*	*Var.Est.*	*F-Ratio*	*Prob F*
Among	36.64	1	36.64	0.1139	0.7364
Within	33783.43	105	321.75		
Total	33820.07	106			

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	20	67.80	19.50
2 - Non-Participants	87	66.30	17.57

ES = .085 β = .4681 1-β = .5319

Test grades were examined from the aspect of course repeaters. Significance at the .05 level was found between first-time and repeating non-participants.

Table 6.

Comparison of First Time and Course Repeating Non-Participants on Unit 1 Test

Source	*Sum of Sqr.*	*DF*	*Var.Est.*	*F-Ratio*	*Prob F*
Among	1461.68	1	1461.68	4.6976**	0.0330
Within	26759.59	86	311.16		
Total	28221.27	87			

**$p < .05$

Group	*N*	*Mean*	*Std. Dev.*
1 - First-Time Non-Part.	57	62.40	18.53
2 - Repeat. Non-Part.	31	70.94	15.85

First time course non-participants' mean of 62.40 (n =57) compared with repeating course non-participant mean of 70.94 (n =31). This significance in non-participants may well be attributed to the familiarity of material by course repeating students. No significant difference was found between first-time and course repeating participants.

Additional comparisons were made in areas of gender and age; no significant difference was found in either category. Complete statistical data on unit 1 test can be found in Appendix B.

In unit test 2, although the participant group had a higher test average than the non-participants, no significant difference was found between participant and non-participant groups. The mean for the participant group was 78.97 (n = 30); the mean for the non-participant group was 74.34 (n =53). Table 7.

Comparison of Participant and Non-Participant Groups on Unit 2 Test

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	410.13	1	410.13	1.9750	0.1637
Within	16820.85	81	207.66		
Total	17230.99	82			

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	30	78.97	13.40
2 - Non-Participants	53	74.34	14.94

ES = .310 β = .3783 $1-\beta$ = .6217

When the factors of age, gender, and course frequency were examined in participant and non-participant groups, no significance was found in any area. Complete statistical data on unit 2 test may be found in Appendix B.

In test #3 a mean of 69.00 (n =35) for the participants compared with a mean of 59.03 (n = 40) for the non-participants. Although 35 students are

included in the statistics for participants, the actual number attending SI sessions was greater. The students who were absent on the day of the test, and were not allowed to make-up the test, would have possibly affected the group mean. This difference is significant only to $\alpha = .10$ and does not meet the significance level set for this study.

Table 8.

Comparison of Participant and Non-Participant Groups on Unit 3 Test

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	1857.34	1	1857.34	3.4454*	0.0675
Within	39352.98	73	539.08		
Total	41210.32	74			

* $p < .10$

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	35	69.00	20.71
2 - Non-Participants	40	59.03	25.20

ES = .396 β = .3483 $1-\beta$ = .6517

In other areas of comparison between participants and non-participants, no significant difference was found between males and females or between traditional and non-traditional students. No difference was found between course repeating participants and non-participants. A difference at the .10 level was found between participants and non-participants who were taking the course for the first time, but it did not meet the criterion level set for this study. Complete data are located in Appendix B.

In the test for unit 4, a statistically significant difference at the .01 level was found favoring participants over non-participants. The mean for the participants was 84.13 (n=30); the mean for the non-participants was 54.02 (n=41).

Table 9.

Comparison of Participant and Non-Participant Groups on Unit 4 Test

Source	*Sum of Sqr.*	*DF*	*Var.Est.*	*F-Ratio*	*Prob F*
Among	15704.99	1	15704.99	45.6109**	0.0001
Within	23758.44	69	344.33		
Total	39463.44	70			

** $p < .01$

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	30	84.13	12.72
2 - Non-Participants	41	54.02	21.83

ES = 1.34 β = .0901 $1-\beta$ = .9099

When the factor of gender was examined, statistically significant differences at the .01 level were found when comparing like-gender participants and non-participants. No significant difference was found when comparing male and female participants or male and female non-participants.

When the factor of age was examined, significance at the .01 level was found between traditional participants and non-participants and between non-traditional participants and non-participants. No statistically significant difference was found either between the traditional and non-traditional participants or between traditional and non-traditional non-participants. It appears that age alone is not a factor in the achievement of academic success in mathematics.

Students who were enrolled in the course for the first time and who were participants in the SI program demonstrated a difference from non-participants in relation to test scores that was significant at the $\alpha = .01$ level. Likewise, course repeaters who were participants demonstrated the same level of significance from non-participants. This was the first instance of an equally significant difference in this area. There was no statistical

significance recorded between participants who were either taking the course for the first time or repeating nor in non-participants who were enrolled for the first or a subsequent time. Two explanations may be made from this information: previous enrollment alone in the course did not give students a significant advantage, and SI was a factor in achieving a "leveling effect". Complete statistical documentation may be found in Appendix B.

Statistics for test 5 showed a difference between participants and non-participants statistically significant at the .01 level.

Table 10.

Comparison of Participant and Non-Participant Groups on Unit 5 Test

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	33.28.87	1	3328.87	8.9568***	0.0040
Within	22299.52	60	371.66		
Total	25628.39	61			

*** p <.01

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	33	83.03	15.87
2 - Non-Participants	29	68.34	22.55

ES = .651 β = .2578 $1-\beta$ = .7422

No significant difference was found when comparing test scores of traditional with non-traditional participants and non-participants. A pairwise comparison of traditional age participants and non-participants revealed a difference at the .01 level of significance. A comparison between non-traditional participants and non-participants was irrelevant due to the fact that all traditional students were participants at this time.

No significance was found when comparing means of male and female participants, male and female non-participants, or when comparing male participants and non-participants. A significance at the .01 level was found

for the second successive time between female participants and non-participants.

Table 11.

Comparison of Female Participants and Non-Participants on Unit 5 Test

Source	Sum of Sqr.	DF	Var. Est.	F-Ratio	Prob. F
Among	3997.86	1	3997.86	10.8083***	0.0029
Within	9617.10	26	369.89		
Total	13614.96	27			

*** p <.01

Group	N	Mean	Std. Dev.
1-Participants	16	84.31	11.07
2-Non-Participants	12	60.17	26.59

ES=.908 β = .1814 $1-\beta$ = .8186

When comparing first time participants with non-participants a statistically significant difference at the required .05 level was found. The same comparison with course-repeating students revealed a lesser, and insufficient, significance at the .10 level. Again the comparison of first-time and course-repeating participants with non-participants revealed no statistically significant difference. Complete statistical data are presented in Appendix B.

Data collected concerning the final exam revealed a difference in mean test scores between participant and non-participant groups that was statistically significant at the α=.01 level with the participant group recording a mean of 68.77 (n = 30) and the non-participant group recording a mean of 51.35 (n =20).

Table 12.

Comparison of Participant and Non-Participant Groups on Final Exam

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	3640.08	1	3640.08	9.4059***	0.0035
Within	18575.92	48	387.00		
Total	22216.00	49			

*** $p<.01$

Group	*N*	*Mean*	*Std. Dev.*
1 - Participant	30	68.77	17.41
2 - Non-Participant	20	51.35	22.69

ES=.768 β= .2206 $1-\beta$= .7794

When the results were examined with respect to the gender factor, significant differences at the .05 level were recorded in both sexes in a comparison of participant and non-participant status. No significance was recorded between the sexes in either the participant or non-participant groups.

Test statistics on the final exam replicated those of unit test #5 with regard to the age factor. Statistical significance at the .01 level was recorded between traditional-age participants and non-participants. A comparison between non-traditional groupings was not possible since all members of that group were participants.

The factor of course repetition was significant in only one area with regard to the final exam. Only those participants and non-participants taking the course for the first time recorded a statistical significance. This significance met the required level of .05. No significance was found between first-time and course repeating participants or non-participants, nor was a difference found between participant and non-participant course-repeating students.

A chi-square analysis was used to determine significance between the control and experimental groups with regard to final course grade. A significance was found exceeding the .01 level.

Table 13.

Comparison of Participant and Non-Participant Groups on Final Course Grade

	A	B	C	D	F	W
SI Participants	6	9	12	8	2	4
Non-Participants	0	3	7	6	20	14

$\sigma = 30.2905$ $df = 5$ $Prob. = 0.0001$

The criterion set for rejection of the null hypothesis, that no difference exists between SI participant and non-participant groups on test scores and final course grade, was determined to be a documented statistical significance on at least three of the course tests as well as on the final course grade. Statistical data from Tables 9-13 support the rejection of the null hypothesis and the retention of the research hypothesis.

Hypothesis #2

The hypothesis was tested through examination of participant's test scores in relation to low, medium, and high levels of attendance in the SI study sessions. The null hypothesis was that there would be no statistically significant difference in low, medium, and high attendance levels in the participating students for each of the five unit tests and the final exam. Significance at the .05 level on at least three of the six course tests was required for rejection of the null hypothesis.

During each of the test blocks, accurate records were kept verifying attendance. Students were required to sign in upon arrival and departure; the presence of the researcher verified these records.

The categories of "low", "medium", and "high" each represent approximately one-third of the possible attendance at all sessions for any given time block. A statistical significance at the required level was recorded

only in two of the test blocks--unit 3 and unit 4. Test block 3 involved the extended time between unit completion and testing due to the spring break. While this was the first instance of significance, it may have been a result of the alteration in testing procedure alone.

In unit 3, the participants engaged in low-level attendance had a mean score of 62.70 (n =23), medium-level participants had a mean score of 75.33 (n =3), and high level participants had a mean score of 83.00 (n =9).

Table 14.

Comparison of Low, Medium, and High Attendance Participants on Unit 3 Test

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	2798.46	2	1399.23	3.7998**	0.0331
Within	11783.54	32	368.24		
Total	14582.00	34			

** p <.05

Group	*N*	*Mean*	*Std. Dev.*
1 (Low)	23	62.70	20.92
2 (Medium)	3	75.33	27.06
3 (High)	9	83.00	9.29

In unit 4, participants engaged in low level attendance had a mean of 78.33 (n =15), medium level attendance had a mean of 88.42 (n =12), and high level attendance had a mean of 96.00 (n =3).

Table 15.

Comparison of Low, Medium, and High Attendance Participants on Unit 4 Test

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	1147.22	2	573.61	4.3697**	0.0227
Within	3544.25	27	131.27		
Total	4691.47	29			

** p <.05

(table continues)

Group	*N*	*Mean*	*Std. Dev.*
1 (Low)	15	78.33	10.21
2 (Medium)	12	88.42	13.45
3 (High)	3	96.00	6.93

Test 4 included supplemental material on negative exponents in radical expressions that was not covered in the text. Participants initially had difficulty with the topic, and it is possible that those high attenders scored a significant difference due to the reinforcement gained in the sessions.

Some students "ran-in" at the last minute for a single visit to prepare for a test and were recorded in the "low" category. It was recognized that they might not fully benefit from the program although it was noted that for some students, a single visit was sufficient to synthesize unit information prior to testing. Two students frequently attended SI sessions but were not active participants in spite of the leader's efforts. Observation records noted that some students attended frequently and were active participants but suffered severe test anxiety and were not able to perform at the same level on the test that had been demonstrated in the study sessions. Although the level of anxiety did decrease over time, it was noted to occur in some degree throughout the semester.

Although a significant difference was found in two test blocks, the remaining four blocks, which included the final exam, showed no difference. The failure to demonstrate significance in at least three test blocks gives cause for retaining the null hypothesis, that no difference exists between low, medium, and high degrees of participation.

Hypothesis #3

An examination of the participation rate in the Supplemental Instruction program between traditional and non-traditional students was possible through acquisition of student records documenting age and sheets

documenting SI study session attendance. Sign-in sheets documenting attendance were tabulated with a categorization of participants in the two age groups.

A breakdown of age with respect to SI participation reveals a pattern. All non-traditional students who remained in the class were SI participants at the end; although the percentage of traditional student participants increased overall, it did not at any time exceed that of the non-traditional students. Table 16.

Supplemental Instruction Participation by Age

	Traditional Age	Non-Traditional Age
Test #1	11/85 (12.9%)	9/22 (40.9%)
Test #2	20/68 (29.4%)	10/15 (66.7%)
Test #3	24/63 (38.1%)	11/12 (91.7%)
Test #4	21/60 (35.0%)	9/11 (81.8%)
Test #5	24/53 (45.3%)	9/9 (100.0%)

The null hypothesis stated that no significant difference would be found in the rate of participation of traditional age and non-traditional age students. Cause for rejection would be a failure to show a higher rate in at least three of the five blocks. Statistics clearly revealed a higher participation rate by the non-traditional students in all of the five test blocks and gave cause to reject the null hypothesis.

Hypothesis #4

The fourth area to be investigated concerned course completion. For purposes of this study, two conditions were set as determining non-completion. The first instance was a withdrawal of the student from the university. Reasons given for the withdrawal were primarily illness of the student or a family member that would require an extended absence from classes, or death of the individual or a family member. The second form of withdrawal was cessation of class attendance without withdrawal from the university.

Students were, as a rule, not allowed to drop the course, but some did discontinue attendance even with the threat of disciplinary action. They were officially withdrawn from the class although they were still enrolled in the university.

End of semester statistics were available on 91 of the original 107 students enrolled at the beginning of the semester. Percentages as well as reasons for withdrawal differed between the participant and non-participant groups. The eighteen students who moved back to the first level developmental class are not included in the data. Four students (9.7%) withdrew in the participant group of 41. This compares with 14 students (28.0%) who withdrew in the non-participant group of 50. These numbers do not include students who were originally enrolled but who were pulled back after the first test. All four of the withdrawing participants left the university for reasons of family or personal illness. Nine of the fourteen non-participants cited the fact that they felt there was nothing they could do to pass the course as their reason for dropping. They got so far behind that they did not believe attendance in Supplemental Instruction sessions could make a difference. Three other students gave their own poor efforts as reasons for lack of success. They believed that success was within their power, but they chose not to try. They planned to attend summer school to make up the credits. Two of the fourteen withdrew due to illness. The determination of a statistically significant difference at the .01 level with regard to course completion gives cause for rejection of the null hypothesis.

Survey Data

The instructor allowed the supervisor-researcher to survey the class at the beginning and end of the semester and at each test block. This procedure allowed the acquisition of information from all students that would probably have not been possible through individual interviews due to commuting and work schedules. Recorded notes of student conversations in the classroom, in

the study sessions, and on the campus were used to document opinions, beliefs, and behavior patterns. It is recognized by this researcher that the information presented through this medium is subject to individual interpretation and that there is always the possibility of unintentional bias.

The first survey was given to students at the beginning of the course; one question asked for the degree of interest that students had in the Supplemental Instruction program, and the remainder attempted to establish the degree to which the students felt that others as well as themselves sought help.

Table 17.

Results of Survey of Interest Level in Supplemental Instruction Participation

High interest	Medium interest	Low interest
60.5%	27.6%	11.9%

A summary of the questions relating to seeking assistance revealed that a majority of students believe that academic assistance is sought about half the time, but they only seek this assistance "sometimes". Friends or peers were the primary source of assistance with course instructors a close second. Surveyed students indicated a strong belief that they affect their own achievement, and most planned to enlist more assistance than they actually did. A complete summary of this survey may be found in appendix B.

In the survey that was given with each unit test, students were asked to rate their level of preparation for the particular test, to estimate the amount of time spent in preparation, to estimate how far in advance of the test that study began, to indicate sources used in preparation, and to rate the test both in difficulty and expected content. The findings in all cases were consistent. A generalization of the summaries across the five units revealed a medium to low level of preparation, the time spent in preparation was one to two hours and this was done the day before the test. There was no difference in preparation when the test had a one or two week lead time. Respondents indicated that the

questions asked were what was expected, and that they were fair in their level of difficulty. The most common study method was working with friends, although Supplemental Instruction and the required math lab setting were also listed as resources used. Students indicated that they utilized their notes, the text, and practice tests in preparation. Very few indicated the use of either a private tutor or the math clinic. Only six total visits by three students were recorded in the math clinic. Two students reported that they had used privately secured tutors for course assistance.

The survey conducted at the end of the semester asked students to compare the grade expectations they had at that time with the expectations they had at the beginning of the semester. Their responses showed some variation. Only the participants indicated a belief that their course grade would probably be higher than they had originally expected at the beginning of the semester. The majority of participants and non-participants indicated that their course grade would be lower than originally expected.

Table 18.

Comparison of End of Semester and Beginning of Semester Grade Expectations of Participant and Non-Participant Groups

	Lower	Same	Higher
Participants	64.7%	20.6%	14.7%
Non-Participants	66.7%	33.3%	0.0%

When asked to rate the instructor as to degree of difficulty, the results reveal some difference between groups.

Table 19.

Degree of Difficulty in Comprehension of Instructor Reported by Groups

	1	2	3	4	5
	Very Difficult				Very Easy
Participants	21.2%	0.0%	24.2%	18.2%	36.4%
Non-Participants	23.1%	15.4%	7.7%	30.7%	23.1%

When the participants were asked if the difficulty of the instructor had determined their participation in the Supplemental Instruction program, 87.5% indicated that it did, and 12.5% indicated that it did not. Participants who completed the survey rated the benefits of the session on a sale of 1 (very helpful) to 5 (not helpful).

Table 20.

Benefits of Supplemental Instruction Sessions for Participants

1-Very Helpful	2	3	4	5-Not Helpful
80.0%	6.7%	6.7%	3.3%	3.3%

Presentation of Qualitative Data

Qualitative data were included as a part of the research design in order to present a more complete picture of the setting than quantitative data alone would have done with the built-in limitations of sample size and design of the study itself. This data is presented in the form of interview results and observations in the classroom and SI study sessions.

Student History and Attitudes

Interviews with developmental students in this study gave an indication that they entered the college setting with varying degrees of apprehension concerning their ability to be successful in the mathematics setting. A large number of students related a history of inconsistent accomplishments and a negative attitude towards mathematics. They had experienced negative reinforcement in the area of mathematics in the past, and this made it harder to get them to take risks now.

A large percentage (86%) of the students reported bad experiences with mathematics education in the public school setting. Most were related as taking place in the elementary setting. These experiences usually included instances in which the student was embarrassed publicly for not understanding concepts or being able to perform skills, perhaps because of insufficient developmental abilities. There were students who could

"remember" exact words of elementary teachers who berated them for non-achievement. Past experiences tended to cause them to withdraw and not attempt active learning. Passive learning was a common element in these students. They learned early to keep quiet, not question, not contribute, but just "get the answer"; once that answer was obtained, there was no reason to examine the process or the reasoning. These traits are supported by the literature (Koch, 1992; NCTM, 1991; Silverman & Juhasz, 1993; Stahl et al, 1992).

Another group (12%) reported that while public education was adequate to even mildly pleasurable, higher education mathematics had provided unpleasant experiences in the form of instructors who were difficult to understand, help that was not readily available, or advising information that was erroneous. When students were asked to give examples of how the university could better meet their needs, the most common request was for information about resources for assistance. Other requests included a slower pace in the mathematics class, more teacher/student interaction, instruction that was clear and understandable, and more patient attitudes towards students experiencing difficulty in class.

A survey of student backgrounds revealed that there tended to be three areas that accounted for their deficiencies: 1) their own admitted deficiencies, 2) deficiencies of the educational system, and 3) lack of background. The student-admitted deficiencies included reasons such as choosing undemanding teachers in high school, getting others to provide answers on homework or tests, failure to do homework or class work, failure to perform at their level of potential, to "playing dumb" to get into special education and do less work.

Education failed the students when it did not hold them accountable for doing their best work. Examples cited included teachers not requiring homework to be either done or turned in, habitually allowing students to check their own work and determine their grades, and not focusing adequately on the course content but rather skipping topics they did not want

to teach or not covering topics to the degree required for mastery. Misuse of tutorial programs allowed students to slip through the system without mastery of content.

A lack of background was the most commonly reported are of deficiency by the older students who had graduated from public school without being required to take any form of algebra. Although the educational system has undergone changes in recent years, the changes came too late for them. These students were frequently apprehensive concerning their own abilities to master concepts and compete with the younger students at this stage of their lives.

Supplemental Instruction - Structure of the Sessions

Observations of content material, study session activities, and participant behaviors and dialogue were recorded for each test block. It was believed that with the knowledge of subject matter being covered, the practices being employed in the study sessions, and the characteristics of the participants in relation to factors such as age and gender, a more meaningful interpretation could be presented in summary.

The structured method of approach was determined from the beginning. In interviews with leaders of other Supplemental Instruction research conducted in higher level mathematics settings such as college algebra or calculus, the leaders reported that it was not uncommon for them to assume a more structured role at the beginning of the sessions. This pattern held true in this study possibly to a greater degree because of the mental attitude of the students in the developmental setting. Students were resistant to participating, and the leader was initially very structured and provided a greater directive role than might be experienced in a higher level mathematics class where a greater expected common base of knowledge may exist. During the first sessions the leader used techniques such as "being a piece of chalk" and writing only what students dictated. Pair problem solving

and jigsaw techniques were not effective in the early stages as interaction between students rarely occurred.

Activities during SI sessions prior to the first test focused on note-taking, text-reading, and interpretation of lecture material. The style most favored for notetaking in mathematics was the Cornell format. The added options of using colored highlighters to code similar topics in class notes was introduced. The value of recopying notes after class in order to practice problem solving as well as organizing material was stressed. A study strategy initiated at the onset was the use of index cards with procedures written in the students' own words and examples worked out by each student in order to provide the opportunity for synthesizing information on process and procedure. The leader provided an additional card with practice problems on one side and answers for self-checking on the reverse for each topic. At the end of the semester students had created a "card catalog" to use in studying for the final exam. Two additional goals in the creation of this card file was providing the students with a familiar anchoring review when they enrolled in the college algebra class at some future time and the skill in creating a resource file that could be transferred to other course concepts. Participants also learned to predict questions and problems that could be expected on the unit tests through an awareness of topic emphasis by the instructor.

Practice test preparation by the students was originally a planned activity for the study sessions, but the pace and structure of the course, combined with the reluctance and uncertainty of the learners, did not allow this. The structure of dual topics covered in most sessions--completed material not yet tested and current material being covered in class--did not allow adequate time to do these. As a result, the leader prepared all practice tests.

One of the study techniques stressed to students at the beginning and in subsequent sessions was the habit of allocating study time each day for working on practice tests and reviewing study cards. This procedure was

implemented because of the instructor's practice of waiting one week after completion of a unit before testing. The time was intended to allow students sufficient study time prior to testing, yet it had the expressed negative effect of requiring students to remember information from one unit while learning material being covered in a new unit. Frustration was expressed and observed. Not all participants engaged in the continual study of completed topics, but a majority stated that they no longer waited until the last minute to work on the practice tests.

The first test was administered after two weeks (5 class meetings) and tested material that either should have been mastered in the first level developmental class or was assumed knowledge for entering students. Departmental practice dictated that students scoring below 60 were required to move back to the first level developmental class unless they contracted to remain by seeking help in some form (SI, math clinic, or private tutoring). Although this agreement was not consistently enforced, it was believed that students who made an effort to conference with the instructor and agree to seek supplemental help would be more likely to make the extra effort required to be successful in the class.

Although no significance difference was found between the mean test scores of the participants and non-participants, the non-traditional participants had a great anxiety level prior to the test, and they were quick to give credit for their success to the study sessions. This endorsement may have been a factor in the increase in session attendance. Attendance records also documented that students from other classes made periodic visits to the SI study sessions; however, the fact that instructors did not always maintain the same pace nor explain procedures in the same way made it difficult for them to have full advantage of the sessions. Connections were not always made when a concept was discussed in terminology that differed from that used by the target instructor. Students from other classes did not attend more than twice.

They stated that the sessions were confusing to them. This was an observed weakness in the program.

During the study sessions prior to the second test, the topics covered included addition, subtraction, multiplication, division, and reducing of rational expressions, complex fractions, ratio and proportion, linear inequalities and variation. Students experienced great difficulty with variation and inequalities. Addition and subtraction of rational expressions created a freeze effect. When encountering a problem involving fractions, participants were observed to stop and verbalize a reluctance, dislike, or lack of comprehension in solving the problem. Students were frequently heard relating negative experiences from early public school in the area of operations with fractions. This verbalization and reluctance in attempt decreased over time with the participants.

Test #2, the first test given after the pull-back exam, was administered one week after completion of the unit and one week after the addition of the afternoon SI session. It was believed by the researcher that the instructor's practice of allowing at least a week to pass after unit completion before the test was given might reveal an added significance between the participant and non-participant groups due to a cognitive Doppler effect. The participants continually reviewed material, and it was doubtful that non-participants did so. In preparation for this test, the participants were given three practice tests and an answer sheet. This enabled them to problem-solve and self-check during the week prior to the test.

The instructor in the selected class did not allow make-up tests. When students missed a unit test, the option of dropping the lowest grade was negated, and the homework/lab grade was used as the fifth grade. If two tests were missed, the homework/lab grade was used as one grade, and a zero was recorded for the other. Although class enrollment did decrease with the progression of the semester, the total number of participants' and non-

participants' grades on any given test did not necessarily reflect the number of students enrolled at the given time.

The format of the tests presented restrictions in performing comparisons between participants and non-participants. On this and all subsequent tests, students were given five problems, each containing an "a" and "b" part; they were required to work any four with the stipulation that both parts of a selected problem must be solved. Item analysis of test questions was not used in this study due to the student's option to select problems for solution. One particular question on the second test revealed a significance between SI participants and non-participants however, and was examined with the design weakness because of its uniqueness. In a class lecture prior to the test, students were shown seven different forms for writing equations of lines. This topic was not covered in the text but rather discussed only in the lecture setting. The class overall did not comprehend the relationship among the various forms, but the SI participants had a setting in which they could examine the relationships. This was an instance in which the study sessions served not only to assist in problem solution but to organize information and examine correlations. The test question asked students to replicate four of the seven forms for writing linear equations and give generalizable examples. This concept was the only "non-problem" item contained in the unit test. The number of participants who correctly answered the question was 93%; this compared with 16% of the non-participants who answered the question correctly.

Participants in the SI study sessions prior to the third test increased in number to a greater degree than that which occurred prior to the second test. One possible explanation for this might have been the lengthened time between unit completion and testing; more students realized the need for review assistance than in previous test situations. The increase in content area topics to be tested and the lower expressed confidence level of the

students might also have accounted in part for this increase in student participation.

One topic covered in the study sessions during this period that provided ethnographic information was that of word problems. This topic again produced a freeze effect initially in the students. They expressed a surety that they had never been able and would continue to be unable to reach solutions. The leader was instrumental in coaxing the participants to make attempts by first allowing students to verbalize their perceptions of the problem and discuss various methods utilized for solutions. Word problems were gradually attempted by the SI participants. This was a lengthy process but one that appeared to provide a confidence towards effort. Observations demonstrating a difference in approaches were made in both participants and non-participants. Participants, who had initially avoided these problems, gradually began to draw diagrams, write formulas, or otherwise list information that they knew about problem relationships. The first steps of being able to formulate problem equations were being taken. Again, the process of different approaches to the problems was stressed. The teaching assistant who graded the papers for this class stated to the researcher that she made it a practice to always grade one word problem in the four usually chosen for a homework grade. Some students never made any attempt at these. An examination of homework papers revealed that these habitual avoiders were not SI participants. The participants did not balk at attempting an effort even though problems were not always completed, and partial credit was not given for incomplete solutions.

Test #3 was given 2 1/2 weeks after completion of the unit and after spring break. Students were tested over the concepts relating to linear equations in two variables, properties and graphs of straight lines, graphing linear inequalities, and the solution of systems of equations by graphing, substitution, and linear combinations.

In the SI sessions prior to the fourth unit test, a decrease in attendance was recorded, yet it marked the first instance in which the number of SI participants exceeded non-participants. Some non-participants had begun a cessation of class attendance precipitated by their poor performance on the third test. Those still attending expressed a belief that they understood this unit better than the previous one. The time frame between unit completion and testing in this block was shorter than the previous one involving the spring break. The addition to the participant ranks has several possible explanations. Word of mouth concerning success of those attending is one option; another may have been that the difficulty of the subject matter caused some to seek help. There is also the possibility of the realization by some that without drastic grade improvement, passing the course would not be an option.

Participants were given only two practice tests prior to the fourth test. The intent of the SI session structure was to withdraw students, prior to the end of the course, from any type of dependency on either the leader or the sessions. Emphasis was on establishing a degree of self-reliance and creating independent learners. The regular attendees did not appear to need the practice tests to the degree they had in the past. Students were observed to be establishing their own review methods.

Test #4 was administered one week after completion of the unit. It measured mastery of the concepts of roots, radicals, and related equations. Students were required to add, subtract, multiply, divide, and simplify radical expressions with supplemental tasks involving negative exponents as well as solve equations involving radicals. The supplemental element was again a depth of topic discussed only in the lecture and not presented in the course text. The SI participants had the advantage of group discussion of concepts.

Student frustration and resistance was high during the period prior to the fifth test. The developmental group overall visibly demonstrated difficulty accepting the concepts of imaginary numbers. It appeared that their life

experiences did not facilitate the comprehension of such abstract concepts. The non-traditional students, in particular, did not easily transfer basic concepts from previous units nor apply them to the topic of imaginary numbers.

Much emphasis was given during the study sessions to the similarity between mathematics operations with complex numbers and algebraic expressions involving variables. Non-participants may not have had an opportunity to make the association. Although on previous topics there were usually some who recalled exposure to the content, that was not the case in this unit. If there had been exposure in past schooling, recall did not occur. Students who had taken the course before admitted to giving up, either physically or mentally, prior to this point. The non-traditional students did not recall the concepts introduced in this unit at all and were the most resistant group. Observed instances of regression occurred in examples such as binomial multiplication of $(x - 7)(x + 7)$ where students would produce the answer $x^2 - 7$. They were frustrated at their new inability to multiply when they previously had been able to perform the multiplication procedure correctly. It was upon the realization that they were employing the short-cut procedures that had been utilized in $(x - \sqrt{7})(x + \sqrt{7})$ that the anxiety was lessened. Understanding where errors were occurring was important to the students.

Test #5 was given in the class meeting following completion of the unit. The two-day time interval was unlike any previous test situation in this class. SI participants were provided with no practice tests prior to the test date. The solution of quadratic equations by various methods with answers involving complex numbers was the primary material included on the test. The introduction of graphing parabolas completed the content by presenting material that is covered at the beginning of the course content for college algebra.

No SI sessions were scheduled after the fifth test and prior to the final exam due to two factors. It was the practice to limit sessions in order to give the student leaders time to study for their own final exams, and previously unmotivated students tended to consume the time and energy of any available resource to make a last-minute campaign to pass.

The progress towards creating independent learners was evidenced as regular attendees expressed the belief that they possessed sufficient study material to use in test review. They did, in fact, arrange among themselves to conduct their own study sessions prior to the test.

The comprehensive final exam was conducted one week after the last class meeting. The design of the study was altered slightly for reporting data on the final exam. Since no formal sessions were conducted between the last class date and the final exam, and since the final was comprehensive, the usual procedure of subdividing test scores into low, medium, and high attendance categories was modified. The total semester attendance at all SI sessions prior to the final exam was used.

Other aspects of the study can best be observed through a factor summary. The participation rate in the Supplemental Instruction study sessions increased overall during the course of the semester.

Table 21.

Overall Percentage of Supplemental Instruction Participation

	Test 1	Test 2	Test 3	Test 4	Test 5
Participants	18.7%	36.2%	46.7%	42.3%	53.2%
Non-Participants	81.3%	63.8%	53.3%	57.7%	46.8%

The decrease in the number of participants in block #4 may have been due to the students' expressed belief that they understood the material better than they had in block #3.

The overall increase in SI participation during test block #4 was reflected by an increase in both male and female participants. The

participation by females showed a consistent increase whereas the rate of participation by males showed a decrease. The comparison of participants percentage within the sexes showed an approximate equivalent increase from test block #5 and test block #1. Male participants compared equally with non-participants at the end of the study; female participants outnumbered non-participants.

Table 22.

Supplemental Instruction Participation by Gender

	Male		Female	
	Part	Non-Part	Part	Non-Part
Test #1	10.3%	48.6%	8.4%	32.7%
Test #2	18.1%	41.0%	18.1%	22.8%
Test #3	24.0%	34.6%	22.7%	18.7%
Test #4	18.1%	40.2%	23.6%	18.1%
Test #5	27.4%	27.4%	25.8%	19.4%

Additional information was gained through summative interviews conducted by the researcher with all SI participants. Students were asked to verbalize the effects that the Supplemental Instruction program had on their learning. New study skills had been learned according to 53.3% of the participants. The specific skills named were ways of organizing information, anticipating test questions, and analyzing problems when seeking solutions. Another benefit named was the feeling of confidence through new understanding of concepts and through the realization that individuals could arrive at correct problem strategies and answers independently of methods demonstrated in the classroom setting.

In an attempt to ascertain whether or not there was a ripple effect from the sessions, participants were asked whether or not they had shared information or studied with non-participants. The majority (63.3%) indicated that they had not. Non-participants who were asked if they had received assistance or materials from a participant were almost equally divided with

53.8% stating that they had received help and 46.2% stating that they had not. It is believed that varying perceptions as to the exact nature of "help" could account for this variation in percentages. The researcher frequently observed participant students helping non-participant students with uncompleted homework prior to class. In some instances participant students copied practice tests for non-participant students, yet they did not consider that they had helped the latter since they had offered no problem solving assistance.

When asked to give reasons for non-attendance, a majority of the non-participants (53.8%) stated that the session times did not fit their schedule. Another group (30.8%) admitted that they simply did not take the time to attend. The third grouping (15.4%) felt they did not need the extra help. When asked whether they would do things differently if the semester were repeated, 66.7% responded in the affirmative.

After this study was approved, the decision was made by the university to add a second developmental math class to its retention efforts. It was not possible because of conflicting times to observe in that setting to a degree equivalent to this study. The similarities and differences are noted for implications for future study.

The second class was the smallest section offered with an initial enrollment of fifty-six (56) students. The instructor was a female who was rated by the students 1.50 on a Likert scale survey conducted at the end of the course (1-easy, 5-difficult). Students stated that she explained things in ways that were easy to understand, and she was available for extra help. Make-up tests were allowed, and homework was accepted late with permission. The highest ten homework grades were used for a homework average; the lowest test grade was dropped.

The SI leader in this setting used a more tutorial approach and frequently was observed explaining and giving answers rather than

facilitating discovery by students. Question and answer format usually placed the leader in the position of questioner and students as respondents. The students in this participant group did not participate in discussions to the degree of students in the first group, and no strong emphasis on alternate methods of problem solution was made.

The composition of the second setting was unique in that students primarily from the lower end of the unit test grade span chose to attend. It was hypothesized that the perception of overall comprehension by the students caused the smaller yet stable attendance in the SI sessions. Attendance ranged from six to eight students and did not vary beyond this in the duration of the term. The increase in participants from approximately 15% to 21% was due to course withdrawals rather than to a larger number in session attendance.

Throughout the semester, in all test situation, the mean test score for SI participants in the second setting was slightly lower than that of non-participants, but there was no statistically significant difference recorded at any time. The instructor stated the belief that SI had made a difference because the class test average overall, in every instance, was higher than in previous semesters. This cannot be attributed to any specific cause because of the possible variation in many factors. It was not possible to know to what degree the study sessions were helping or what those students' grade might have been without the assistance.

This group logged-in no time in the math clinic and did not admit to securing private tutoring. Studying with friends and utilization of the required math lab were cited as resources prior to tests. This group did not have the benefit of practice tests in study sessions, but they were given teacher-made practice tests during a class meeting as a method of study. There also was not an extended time between unit completion and test dates. The instructor traditionally tested on the next class meeting after unit completion.

The grade distribution for final course grades shows no significance difference between participant and non-participant groups.

Table 23.

Grade Distribution for Second Supplemental Instruction Group

	A	B	C	D	F	W
SI Participants	0	2	1	5	0	2
Non-Participants	5	7	10	12	4	8

X =4.2283 df = 5 *Prob.* = 0.5170

It was observed that although none of the participants made an "A" as a final course grade, no participant received an "F". The instructor did claim that the overall class performance was higher than that in previous classes, but this cannot be verified or attributed to Supplemental Instruction.

No significant difference was found in the area of course retention. Two of the ten (20.0%) participants withdrew compared to eight of the forty-six (17.4%) non-participants. The small sample size in the second setting and the differences in instructor and leader habits reinforce the need for additional studies in relation to sample size, instructor effect, and leader effect.

The two classes whose statistics are reported provided very different settings in terms of structure of the class, SI leader characteristics, and instructor characteristics and practices. It is believed that the benefit from the apparently contradictory findings would be to isolate the variables and conduct additional studies.

Supplemental Instruction - Observation Summary

Observation of the procedures followed in SI study sessions provided additional insights. The characteristics and habits of the group constantly changed during the semester. Often the topics under study in the class affected group behavior, attitudes, and coping methods.

The initial participants in Supplemental Instruction had certain characteristics. In the area of gender, the percentages of participants and non-participants reflected the proportionate class composition of 58.9% males

and 41.1% females. The participant group was composed of 10.3% males and 8.4% females; non-participant composition was 48.6% males and 32.7% females.

Participants tended to be students who were aware that they were weak and were seeking help. For some, there was virtually no solid mathematical base from which to work.

Participatory learning was not quickly embraced. The participants were initially very reluctant to contribute to the study sessions. They not only had difficulty in expressing concepts to each other but to the leader as well; open-ended questions were frequently left open. The developmental students were not comfortable in being asked to examine cognitive processes or to contribute to a discussion concerning mathematical content or process. One factor in the degree of success of the SI program was speculated to be the degree to which students were active, participant learners in the study sessions. In a continuum ranging from passive learning (being shown process and told answers) to active learning (facilitated discovery of solution and opportunities to verbalize processes), the degree of success that the developmental students experienced appeared to be dependent upon their position on the continuum.

After one month, the initial reluctance of the regular participants towards verbal responses had changed. In the "safe" environment of the study sessions, students began to feel comfortable in asking questions. This same rise in questioning began to be evident in the classroom setting. Initially there was no observed questioning by students; only three students were noted to make delayed responses when the instructor asked questions of the class. After seven weeks, students who were participating in the SI study sessions began infrequent questioning in class concerning the instructor's procedures; the questions related to alternate methods of problem solutions. Their frequency of response to instructor questions, however, did not increase.

The Supplemental Instruction sessions focused heavily on ascertaining each student's base level of understanding, methods of solution, and moving towards solution from that point. A primary focus moved towards the examination of each individual's method. It was deemed important that the option of alternate methods of solution be stressed. When students were allowed or required to verbalize processes, it was apparent that thought patterns did indeed follow different routes. An example of this was the solution of the problem *5/7i* contained in an assignment. One student stated that both numerator and denominator must be multiplied by *"7i"* in order to rationalize the denominator. Another advocated that since the *"i"* was the only problem, multiplying the numerator and denominator by *"i"* was sufficient. A third student recalled that the instructor had stated that one must multiply by conjugates and therefore multiplication by *"-5i"* was the correct procedure. All three were invited to demonstrate their solutions, and the observing group agreed to the correctness of their common answer. This type of sharing occurred repeatedly in the safe environment of the study sessions. This one practice possibly did more to increase the participation level of the group than any other. Through the frequent discussion and demonstration of one individual's analysis and procedure, others began to feel comfortable in expressing their own methods. As participating group members began to feel comfortable in exploring alternate options, they began to ask questions of the instructor in class as well whereas previously all class members remained silent even when they were asked if there were questions. Expanded verbalization became evident through the semester as towards the end of the term students regularly came into the sessions with questions or ideas that they wanted to ask of or share with other group members.

Verbalization was observed to reinforce learning in another aspect as students felt at ease in discussing their errors. Frequently when students did poorly on tests they accepted the grade given, seconded the belief that they did

not understand, and demonstrated a frustration or resignation to failure. It is believed that this reinforced the passivity of the learner and lessened future efforts to be successful. When students spent time in SI examining errors, they were able to understand the exact nature of their mistakes, and frequently this lessened their sense of being inadequate. The expressed awareness that their mistakes were simply due to carelessness, a failure to complete the problem, or a misunderstanding of what was asked seemed to alleviate their belief that they did not understand. This realization that an error was not caused by lack of understanding of content was observed to instill a type of self-confidence in the students.

As sessions progressed through the semester, changes could be observed not only in the verbal participation of the students but in the written work as well. In the beginning, problem-solving was usually done by the students in very deliberate steps with only one procedure being utilized in a solution line. After two months, some students were observed performing multiple operations in one line of problem solving. An example of this was regrouping and moving decimal places simultaneously.

As students firmly grasped concepts, they often developed individual shortcuts. When a shortened process was observed, the leader frequently asked the students to explain the rationale. As a rule, they were unable to do this initially, but when individuals were pressed for an explanation and had difficulty, the group would often join in supportive participation. It was observed that instructors often explain a procedure in detail and then offer a shortcut which simplifies the process. Examples of this can be found in cancellation in fraction multiplication or reduction, regrouping terms in relation to an equality sign, or multiplying or dividing by powers of ten. As this observer watched the developmental students work through various problems on a number of topics, it became evident that at some point in comprehension, a student would discover a shortcut. Each had his own

manner of expressing the new-found procedure. When that shortcut was shared with another student, however, the other did not automatically move to the new level of understanding, and if not, often expressed confusion with the different technique. It appeared that students who had reached some arbitrary level of comprehension could then also embrace the shortcut method; however students who had not attained that "level" were only confused by the alternate method. This led the researcher to hypothesize that one cannot "give" another a shortcut; when a sufficient level of comprehension has been attained, individuals will arrive at their own methods.

The greatest benefit of the SI sessions was the chance for discovery of multiple approaches for solutions, and this was most evident in the area of word problems. The leader very deliberately emphasized multiple approaches to problem solving by asking a number of students to verbalize or demonstrate their approach to a problem solution. Most often a variety of approaches could be found. If this were not the case, of if a minimum of options were used by the students, the leader directed the participants to discover other alternatives. One item noted by the researcher concerned the tendency of the instructor, when demonstrating problem solution procedure, to indicate that he was showing the students "the way" to solve the problem. When asked if he considered that the phrase implied the utilization of only one correct procedure he responded that while it was not intended, it was a possible perception by students. When students were asked the same question, they replied in the negative but added that it was usual procedure for them to assume that one primary method of solution existed in most cases. It is the belief of this researcher that additional studies in this area might provide insights.

The process of allowing and encouraging students to demonstrate alternate methods of problem solution was particularly valuable during test

time. Unit tests always included at least one problem that was presented in a format that had not been covered either in class discussions or on homework assignments. The discussion of process that occurred during the SI study sessions allowed students to develop a procedure for analyzing a given problem as the transfer of some other problems that had been covered.

Another change observed in the course of the study sessions was in the area of group dynamics. Although the group was in a constant state of flux, the core grouping developed its own identity and personality and affected the fringe group. A definite camaraderie had developed between the members of the nucleus group, and they did not hesitate to assist any newcomer or drop-in. A voluntary telephone list created at the beginning of the semester was used by members to contact each other with questions. The core students stated the realization that their explanations to others benefited them in reinforcing concepts.

Another behavior change in study sessions noted at a 5-6 week point was the emergence of "sub-leaders" in the group. On one occasion when the leader had to be absent, the group decided to meet and work things out among themselves. The group determined that by working together, and using their individual strengths, they could ultimately solve the problems. The particular assignment for the day involved word problems. The group verbalized that certain members were skilled in setting up equations, and others were skilled in the solution. Should a problem involve fractions or decimals, members were identified who had little difficulty in those areas. The group's method of helping each other was their own awareness and utilization of each individual's strengths.

The literature states that learning which can be anchored to prior knowledge is more effective (Annis, 1983; Garfield, 1988; Lampert, 19888; Thomas & Rohwer, 1986). This became evident in the SI sessions. When one student had difficulty in understanding a concept as demonstrated by the

professor during a previous lecture, another student would share his/her own understanding in a manner which usually anchored the concept to some real-life situation. If connections did not take place from this sharing, another student usually picked up the task until a connection was made. This sharing proved a great benefit.

During the initial study sessions the females were observed to be more reluctant to participate. They tended to rely on males in the group to reach solutions. When the emphasis was on verbalization and multiple approaches, the females began to demonstrate a higher degree of participation. They were also more frequently observed to question classmates, the leader, and the instructor in the classroom setting. The language element appears to be an important factor in female comprehension. On two occasions female members of the study group commented that procedures explained by males were difficult to understand. One reference was to the instructor's explanation of word problems relating to mixtures, and the other was to a classmate's explanation of slope.

Outlook for the Future

In previous studies, it was observed that when students enrolled in a sequel course without the benefit of Supplemental Instruction, the increase in grade achievement did not continue. Kenney (1989) theorized that students were not able to replicate the SI setting. The creation of independent learners who could transfer the skills learned in this setting to other and future subjects was a goal of the program. For that reason, the leader allowed students to assume a greater role in the study sessions. Notes were recorded in which students made references to methods that could be used in their chemistry class for problem solutions, and the techniques of test preparation that could be applied to other courses.

By the close of the semester, those who had been attending regularly had developed a very evident confidence and needed only periodic assistance

or direction. Questions that at the beginning of the semester were worded as "how do you do this one?" had changed to "can someone help me find my mistake in this problem?". An example of the progression of student thinking near the end of the course can be illustrated by comments made by students when checking their work with answers in the back of the book. Early in the sessions, a student's answer of 2 1/2, when compared with an answer of 5/2 in the book, elicited a response indicating the surety that the student had in fact missed the problem. There was seldom recognition of a correct answer in another form. After much elaboration in the sessions concerning equivalent forms of expressions students began to analyze whether their answer was another form of the answer provided in the text. Near the end of the semester, on one occasion, an overconfidence could be observed in the instance when a student checked the book to discover an answer that bore no resemblance to the one she had obtained. The student stated that the book was obviously incorrect.

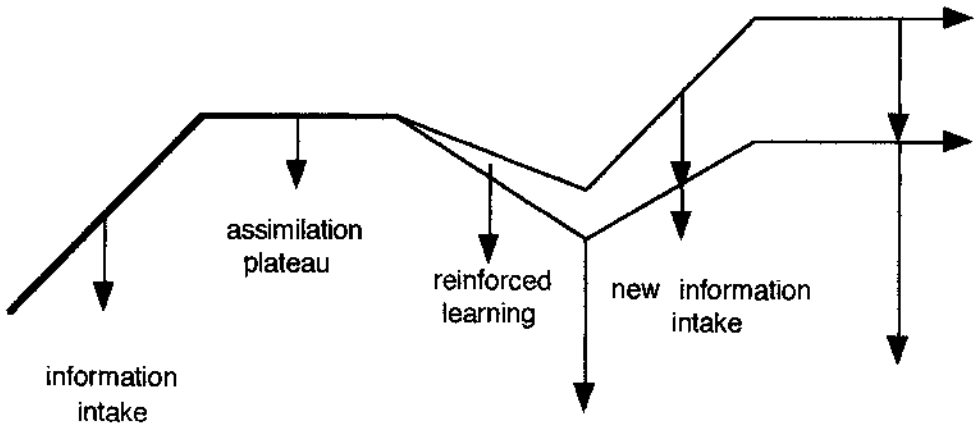
Other indicators gave evidence that students were progressing both in confidence and independence. Initially the leader was the resource individual for all information; as the semester progressed, the students did not automatically turn to the leader for assistance but rather to other class members. Times were observed when the students appeared to perceive the leader as an intrusion in the discussion of the students. Towards the end of the semester, the leader served only to bring focus to higher level thinking; participants were even posing other problem options themselves.

An observation connected with the developmental students in this study precipitated a hypothesis by the researcher and dealt with the pattern of progression/regression that often accompanied learning of new concepts. There appeared to be an increase of cognitive intake followed by a plateau period of assimilation of information. This plateau was followed by a regression dip in which the student questioned the information received. It is

believed by this researcher that what happens in this period affected future learning. The dip of unreinforced learning may cause the student to believe that no knowledge has truly taken place. This event may take place after the completion of one lesson and prior to the next learning intake. Most often it occurs again prior to a test when students are attempting to organize and summarize information. It may be during this period that developmental students can benefit most from reinforcement. It is believed that they initially seek to have the material retaught or answers provided. It was the practice in the SI sessions, when this occurred, to refrain from giving answers or reexplaining procedures but rather to have the uncertain student explain procedures or hypothesize answers. The practice appeared to move the student out of the regression dip and on to a higher level of confidence. This seemed to have a continuing effect in that in subsequent situations the dip was slighter and movement out came quicker.

Figure 1.

Reinforcement Learning Diagram



The data collected as a result of this study is broad in scope. Both quantitative and qualitative aspects have hinted of possible generalizable truths. The limited sample size, the short time frame of the study, and the absence of consistent practices in areas of content presentation and testing practices make it difficult to draw firm conclusions. It becomes the task of this

and other researchers to consolidate those findings and use them to project a path for future studies.

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Hypothesis Findings

The findings in this study of the effects of Supplemental Instruction (SI) between participant (experimental) and non-participant (control) groups uphold findings from previous investigations of the program itself and raised other questions to be investigated in future studies of developmental math students. These findings may be divided into two primary areas: those documented by statistical evidence and those conclusions reached by the researcher through observations and interviews.

Quantitative Findings

Hypothesis #1 - A higher test average on each of six tests will be found in students participating in the Supplemental Instruction program from those who do not.

Table 24.

Summary of Significance over Test Blocks

	Participant Mean	*Non-Participant Mean*	*Significance*
Test #1	67.80 (n=20)	66.31 (n=87)	--
Test #2	78.97 (n=30)	74.34 (n=53)	--
Test #3	69.00 (n=35)	59.03 (n=40)	p <.10
Test #4	84.13 (n=30)	54.02 (n=41)	p <.01
Test #5	83.03 (n=33)	68.34 (n=29)	p <.01
Final Exam	68.77 (n=30)	51.35 (n=20)	p <.01

No significant difference between participant and non-participant groups was found on the first two unit tests; insufficient significance was

recorded on the third unit test when comparing groups on factors of participation alone. The required statistical significance in the last three tests combined with the significance at the .05 level in final course grade documented in Table 23 give cause for rejecting the null hypothesis and retaining the research hypothesis.

Hypothesis #2 - A higher test average will be found in students who exhibit a high degree of participation in the Supplemental Instruction program than in those who exhibit a low degree of participation.

Table 25.

Comparison of Supplemental Instruction Effects with Attendance Factor

Test	1	2	3	4	5	Final
Significance	-	-	.05	,05	-	-

A significance with regard to attendance factors was found only in the third and fourth test blocks. No overall significant difference was found between test scores of students of high and low attendance levels although it is noted that in two of the six test situations some significance was found that met the required level. The requirement for rejection of the null hypothesis was a failure to show significant difference in at least three of the six blocks. Based on the data in Table 25, the null hypothesis is retained.

Hypothesis #3 - A higher participation rate in the Supplemental Instruction program will be found in the non-traditional (age 23 and over) students than in traditional (under age 23) students. A higher rate of participation in three of the test blocks was required for rejection of the null hypothesis. Only the five unit tests were used in this comparison since there were no formal study sessions prior to the final exam. In each of the test blocks the rate of participation by the non-traditional age students was more than double the rate of participation by the traditional age students. The data presented in Table 26 give cause to reject the null hypothesis in this case, but a

caveat is given that this hypothesis might not be generalizable. The research hypothesis could well be rejected in future studies.

Table 26.

Supplemental Instruction Participation by Age Factor

	Traditional Age	Non-Traditional Age
Test #1	11/85 (12.9%)	9/22 (40.9%)
Test #2	20/68 (29.4%)	10/15 (66.7%)
Test #3	24/63 (38.1%)	11/12 (91.7%)
Test #4	21/60 (35.0%)	9/11 (81.8%)
Test #5	24/53 (45.3%)	9/9 (100.0%)

Hypothesis #4 - A higher rate of course completion will be found in students who participate in the Supplemental Instruction program than in those who do not.

Four of the forty-one students who participated at some point in the course (9.8%) withdrew before completion of the course; this compares with fourteen of the fifty non-participants (28.0%) who withdrew. A chi-square analysis was used to determine significance. A statistically significant difference at the .05 level was found. Based on the data presented in Table 27 the null hypothesis is rejected and the research hypothesis is retained.

Table 27.

Comparison of Participant and Non-Participant Groups on Retention

	Withdrew	Remained	Total
SI Participants	4	37	41
Non-Participants	14	36	50

$\sigma = 4.7254$ $df = 1$ $Prob. = 0.0297$

Findings in this study support other Supplemental Instruction research in the area of course retention, and it is believed that this hypothesis is generalizable and can be supported in other studies of developmental students.

Summary of Other Quantitative Findings

When test blocks were broken down in pairwise comparisons using factors of gender, age, attendance, and course history, additional statistical findings that were not originally hypothesized were discovered. The first category examined is that of gender. Beginning with the fourth test block and continuing through the final exam, female participants showed a statistically significant difference from female non-participants in test scores; male students showed a statistical significance only in the fourth and final test blocks, although the significance level at those times equaled that of the females.

Table 28.

Comparison of Supplemental Instruction Effects With Gender Factor

Test	1	2	3	4	5	Final
Male Significance	-	-	-	.01	-	.05
Female Significance	-	-	-	.01	.01	.05

Another facet of the test block study that showed statistical significance in all blocks except the second was the comparison of participants and non-participants taking the course for the first time. The significance in the third block was only at the .10 level, but the .05 level set for this study was either met or exceeded in the other four blocks. In only one test block did repeaters show a significant difference, and that was in the extended test block #3.

Table 29.

Comparison of Supplemental Instruction Effects with Course Frequency Factor

Test	1	2	3	4	5	Final
First-Time Student Significance	.05	-	-	.01	.05	.05
Course-Repeater Significance	-	-	-	.01	-	-

The third factor examined was traditional versus non-traditional status. Traditional-age participants paralleled the overall results and demonstrated a

statistically significant difference over non-participants in the last three test blocks. A comparison was not possible with the non-traditional students since no non-traditional non-participants existed in the last two test block analyses. A statistically significant difference at the required level was found in the fourth test block.

Table 30.

Comparison of Supplemental Instruction Effects with Age Factor

Test	1	2	3	4	5	Final
Traditional Student Significance	-	-	-	.01	.05	.01
Non-Traditional Student Significance	-	-	-	.05	*	*

* No members in the group

Additional pairwise comparisons were made and included in the summary of Supplemental Instruction significance.

Table 31.

Summary of Supplemental Instruction Significance

Test.	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1.	.	.	.	.	.	.	.05	.	.	.	.	.	.	.
2.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.	.10	.05	.	.	.	.	.	.	.	.	.	.	.	.
4.	.01	.05	.01	.01	.	.10	.01	.01	.	.	.01	.05	.	.
5.	.01	.	.	.01	.	.	.05	.10	.	.	.05	.	.	.
Final.	.01	.	.05	.05	.	.	.05	.	.	.	.01	.	.	.

A - Overall comparison of SI participants and non-participants

B - Comparison of low, medium, and high attenders

C - Comparison of male participants and non-participants

D - Comparison of female participants and non-participants

E - Comparison of male and female participants

(table continues)

F - Comparison of male and female non-participants

G - Comparison of first-time participants and non-participants

H - Comparison of repeating participants and non-participants

I - Comparison of first-time and repeating participants

J - Comparison of first-time and repeating non-participants

K - Comparison of traditional participants and non-participants

L - Comparison of non-traditional participants and non-participants

M - Comparison of traditional and non-traditional participants

N - Comparison of traditional and non-traditional non-participants

Qualitative Findings

Qualitative findings are, by their nature, open to a more subjective interpretation than quantitative findings. Attendance at all study sessions and class meetings combined with recorded notes of interviews and students' expressed concerns in the classroom setting were attempts at minimizing this possibility. The findings of the researcher are presented as hypotheses with supporting evidence from this study. They are subject to interpretation and future research verification or disputation by others.

1) Math histories written during the course of this study showed that 93% of the students expressed a negative attitude towards mathematics.

2) The developmental mathematics student frequently mentions an unfamiliarity with problem-solving processes. The more difficult the material, the more often comments are made that there has been no previous exposure to it.

3) The developmental mathematics student participates in SI to the degree of perceived instructor difficulty. Interviews observations, and surveys obtained from two SI groups provided data for this claim.

4) The degree of success from the SI program will depend on the degree to which students are active, participatory learners in the sessions. The two

students who maintained a passive role throughout the semester in the study sessions were also the two students who received a course grade of "F". Observation and test records were used as a basis for this hypothesis.

5) Students who could make some type of connection to information being presented with some element in their own experiences appeared to understand concepts and procedures quicker than students who had no reference point. Observations in the study sessions and class lectures provided a basis for this claim.

6) Students who had learning reinforced were able to move to subsequent concepts quicker and with more confidence than those who did not. This was observed in situations where participants were asked to correct homework and test papers and explain why mistakes had been made. As a rule, non-participants did not do this, since it was not a course requirement.

7) Students scored higher on tests in which the questions asked matched the type and level of difficulty as those presented in class prior to the test. On two of the unit tests, question were asked in a higher format than was presented in class. These tests recorded the greatest difference in group means.

Quantitative Conclusions

Based on information obtained with respect to the four hypotheses, conclusions were formed that may explain and further elaborate on the data.

1) The significance of the Supplemental Instruction program at the required level only on the last three exams suggests that the effects of SI may be cumulative in nature. The significance found later in the study may be the result of the foundation that was laid earlier in the study sessions.

Towards the end of the semester some students had quit attending class and were not present for the tests. Had they been in attendance, there is the possibility that their scores would have altered the differences between the

two groups. From conversations with these students and their expressed frustration with the ability to comprehend material, this researcher has some reason to believe that they would not have scored well on the tests. It is doubtful that any change in significance would have resulted in the first tests, but it is very possible that had they taken the later tests a higher significance might have been found.

2) Attendance alone in study sessions did not guarantee academic success. Each student possesses a particular need for assistance and a degree of readiness to accept assistance. Statistical significance was recorded in only the third and fourth test blocks. This significance could have been merely a chance occurrence, however the third test did occur after an extended time lapse between unit completion and test date. The time factor may have accounted for some significance in students who were high attenders. The fourth test included difficult supplemental material that was not presenteded in the text but covered only in the class lecture setting. High attenders in the SI study sessions had opportunities to synthesize the information and gain a better understanding. Observations revealed that some low attenders were students who got serious about content comprehension only immediately prior to the test date. Other students used the study sessions primarily to review material prior to testing. In these cases there existed the possibility for low attending students to obtain high or low test scores thus nullifying the concept that low attendees would tend to earn low test scores.

The same reasoning may be applied to high attenders. Some students did well on tests because of frequent attendance at study sessions. Others, however, were observed to comprehend subject material, to make applications of concepts, and to be able to verbalize process and reasoning, yet when faced with actual test situations they were unable to perform on even the most basic level. Test anxiety was one reason given for their "less than desirable"

performance. The anxiety did decrease in varying degrees in most participants during the semester, but it did nullify the belief that high attendance would tend to guarantee success in test situations.

3) While it appeared that non-traditional students took advantage of the Supplemental Instruction program to a greater degree than the traditional students, the statistics alone representing the participation levels do not fully represent the situation; extenuating factors must be taken into account in order to understand the significance. The older students were quick to recognize a need for help. While the percentage of non-traditional participants at the end of the semester was impressive, it was recognized that had initial session times not been extended to include afternoon times, there was a strong probability that the percentage would have been less due to a number of factors such as employer or family responsibilities. The large number of traditional students enrolled in the course made it unlikely that such a high percentage of students would be able to participate even if there were the desire to do so. It is believed that the small sample size of non-traditional students does not give an appropriate representation.

4) The rate of course retention appears to be enhanced by the Supplemental Instruction program. This study maintained the same level of significance of other SI studies across all disciplines.

5) The aspect of increased verbalization for females appears to result is greater achievement and is an area that merits more study. Additional studies may verify or dispute the tendency of females to exhibit improvement in the area of mathematics given the chance to verbalize processes. Additional research may likewise support or dispute the pattern in males.

6) When the variable of repetition is applied to participant and non-participant groups, a significance, if it is found, tends to be with first-time course students rather than course repeating students. Familiarity with

content may nullify some of the benefits of Supplemental Instruction, depending on the number of repetitions, the particular instructor, and method of presentation.

7) Age is not a factor in student achievement. Other variabless such as efficacy issues may be connected to the age factor.

Qualitative Conclusions

1) The developmental mathematics student has a negative attitude about mathematics that probably had origins in public elementary school and is reluctant to actively participate in the learning process now.

2) The developmental mathematics student has limited recall of previous learning. One possible reason for this may be the time lag between exit from public school and entrance in higher education. If this lapse is severe, it is questioned as to whether or not true learning actually occurred. Another explanation possibly stems from material being presented in a manner in higher education that is different from that previously experienced, and little or no connection is made. The procedure mechanics have been forgotten. Interviews and observations documented this claim.

3) An instructor who is "difficult to understand" will elicit a higher participation rate than one who is perceived by students as "easy to understand". In the former case, participants may tend to be either evenly distributed or from the upper end of the grade distribution curve; the lower end students give up earlier. In the latter case, the students who participate may tend to be from the lower end of the curve.

4) On a continuum ranging from passive learning to active learning, the degree of success that the developmental student will experience depends on the individual's position on the continuum.

5) Learning that has a connection has a greater chance of moving in to long-term memory. There must be some common area of connection

established by the teacher and learner before the teacher can move the learner to new levels. If that connection is not made, either by the teacher or some other assistance form, short-term imitative performance may occur, but it will not move to long-term retention, but rather it may be lost. This may very well be the case for students who had no recall of prior experience with given topics.

6) Learning that is reinforced provides a base upon which subsequent learning can take place and may be a factor in the move to higher levels of learning, improved confidence, and higher self-esteem of the learner. This hypothesis was reached from interviews and observations in the SI study sessions and presented in a graphic form created by the researcher. The representation of this concept in Figure 1. represents an incline of learning intake followed by a plateau of assimilation. Students in the study appeared to need a time that was free of additional information in which they could structure and restructure information in a pattern that fit their individual learning habits. This is a general representation and may actually be a series of inclines and plateaus. The next phase of the diagram is a period of decline in which the student reviews the intake in order to ascertain, with the passage of some time, whether the concepts have been retained and can be either recalled or applied correctly. The extent and duration of decline, like intake, is variable and dependent on a situation and the particular student. If this period of decline is reinforced through adjustment, correction, or confirmation, the student then moves on to a new cycle of intake. If the period of decline is not reinforced, a student may determine that no true learning has taken place and be reluctant to participate in the learning effort in the future. Attutides and self-esteem may decline as well.

7) Participants in classes with instructors whose test format is congruent with their teaching format may not demonstrate the degree of

significance with respect to Supplemental Instruction of instructors whose tests require evaluation, synthesis, or some higher level of application of course material than was covered in class.

Recommendations for Future Research

This study was unique in that it examined the effects of Supplemental Instruction in a developmental setting; it moved outside the traditional guidelines for examining statistical significance by looking at individual test blocks within the overall study. It is only the first of many that are needed in order to ascertain if the hints of significance found here hold true and are generalizable to the developmental population overall.

Future studies are needed to examine a generalizable pattern of significance in developmental classes.

The study did not evaluate the effects of the instructor nor of the leader, but a strong realization of the need was reinforced due to the dissimilar nature of the two leaders and instructors mentioned in this study. It is suggested that a study involving a larger sample and multiple instructors be conducted. Further studies are suggested in the area of leader evaluation. It is critical that the mathematics leader not revert to the practice of becoming a mini-professor who merely reteaches the lesson. If that occurs, then the SI sessions lose their uniqueness.

Additional studies may verify or dispute the importance of verbalization in problem-solving for improvement in mathematics achievement in females.

Studies involving the establishment of a covariate in the form of prior knowledge, intelligence, motivation, or pretest scores would be valuable since this study did not control for any of these variables.

Since many mathematics classes have computer labs available in conjunction with course requirements, the effects of Supplemental Instruction in conjuction with computer assisted instruction merits study.

The significant problem of underprepared students is not a new one, and it does not promise a quick end. Albert Einstein said, "The significant problems we face cannot be solved at the same level of thinking we were at when we created them." Higher education must examine the broad scope of its needful students and move outside paradigms of the past if it is to adequately offer realistic solutions for the future. It is hoped that this research can provide at least one clue in the quest for answers.

APPENDIX A

Test Survey

Please complete this survey after you finish the test.

Rate your preparation for this test (circle one). (Low) 1 2 3 4 5 (High)

When did you start studying for this test? (Check only one)

_____ more than 5 days ago

_____ 3- 4 days ago

_____ 2 days ago

_____ yesterday or last night

How many hours did you study for this test? (Check only one)

_____ none

_____ 1-2 hours

_____ 3-4 hours

_____ 5-6 hours

_____ more than 6 hours

What did you use in preparation for this test? (Check all that apply)

_____ computer _____ math lab _____ math clinic

_____private tutoring _____ S.I. _____ studying with friends

What materials did you use to study for the test? (Check all that apply)

_____ notes _____ textbook _____ chapter test _____practice tests

In general were the problems (check one)

_____ too hard _____ okay _____ easy _____ too easy

This test was what I expected. (circle one) Yes No

How anxious do you get before a math test? (Very) 1 2 3 4 5 (Not at all)

How does this compare with other subject tests? (check one)

___ Less ___ About the same ___ More

If you attended an SI session to study for this test, how helpful was it? (Check one)

____ a lot _____ some ____ only a little _____ none

If you have not attended any SI sessions, why not? (Check one)

____ don't have the time _____ don't think it would help

____ the times aren't convenient _____ prefer to study another way

If you would like to make any comments, please use the back of this page. The instructor will not see these papers.

APPENDIX B

Unit 1 Supplemental Instruction Test Statistics

Comparison of Participants and Non-Participants - Test #1

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	36.09	1	36.09	0.1122	0.7383
Within	33767.82	105	321.60		
Total	33803.91				

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	20	67.80	19.50
2 - Non-Participants	87	66.31	17.57

Comparison of Low, Medium, and High Attenders - Test #1

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	489.06	3	163.02	0.5040	0.6804
Within	33314.84	103	323.45		
Total	33803.91	106			

Group	*N*	*Mean*	*Std. Dev.*
1 - Low Attenders	9	63.44	19.41
2 - Medium Attenders	2	79.00	1.41
3 - High Attenders	9	69.67	21.66

Comparison of Male and Female, Participants and Non-Participants - Test #1

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	336.48	1	336.48	1.05	0.3089
Columns	63.26	1	63.26	0.20	0.6584
Interaction	456.36	1	456.36	1.42	0.2365
Error	33148.78	103	321.83		
Total	34004.88	106	320.80		

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Male)	63	64.71	18.78
2: (Female)	44	68.32	16.57
Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	20	67.80	19.50
2: (Non-Participants)	87	65.83	17.63
Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Male Part.)	11	62.27	21.12
1 & 2: (Male Non-Part.)	52	65.23	18.43
2 & 1: (Female Part.)	9	74.56	15.86
2 & 2: (Female Non-Part.)	35	66.71	16.59

Comparison of First-Time and Course Repeating, Participants and Non-Participants - Test #1

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	1384.04	1	1384.04	4.26**	0.0415
Columns	93.16	1	93.16	0.29	0.5934
Interaction	125.65	1	125.65	0.39	0.5353
Error	33772.78	104	324.74		
Total	35375.63	107	330.61		

** $p < .05$

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (First Time)	71	63.27	18.98
2: (Repeating)	37	70.81	15.62
Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	20	67.80	19.50
2: (Non-Participants)	88	65.41	17.96
Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (First-Time Part.)	14	66.79	21.35
1 & 2: (First-Time Non-Part.)	57	62.40	18.45
2 & 1: (Repeat Part.)	6	70.17	15.79
2 & 2: (Repeat Non-Part.)	31	70.94	15.85

Comparison of Traditional and Non-Traditional, Participants and Non-Participants - Test #1

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	272.06	1	272.05	0.85	0.3593
Columns	36.09	1	36.09	0.11	0.7381
Interaction	441.65	1	441.65	1.38	0.2434
Error	33054.12	103	320.91		
Total	33803.91	106	318.90		

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Traditional)	85	67.40	17.07
2: (Non-Traditional)	22	63.45	20.76
Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	20	67.80	19.50
2: (Non-Participants)	87	66.31	17.57
Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Trad. Part.)	11	73.09	14.43
1 & 2: (Trad. Non-Part.)	74	66.55	17.36
2 & 1: (Non-Trad. Part.)	9	61.33	23.60
2 & 2: (Non-Trad. Non-Part.)	13	64.92	19.42

Unit 2 Supplemental Instruction Test Statistics

Comparison of Participants and Non-Participants - Test #2

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	410.13	1	410.13	1.9750	0.1637
Within	16820.85	81	207.66		
Total	17230.99	82			

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	30	78.97	13.40
2 - Non-Participants	53	74.34	14.94

Comparison of Low, Medium, and High Attenders - Test #2

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	428.77	2	214.39	1.2114	0.3134
Within	4778.19	27	176.97		
Total	5206.97	29			

Group	*N*	*Mean*	*Std. Dev.*
1 - Low Attenders	16	81.69	11.90
2 - Medium Attenders	9	73.22	13.91
3 - High Attenders	5	80.60	16.62

Comparison of Male and Female, Participants and Non-Participants - Test #2

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	240.02	1	240.02	1.15	0.2866
Columns	410.13	1	410.13	1.97	0.1647
Interaction	105.05	1	105.05	0.50	0.4800
Error	16475.78	79	208.55		
Total	17230.99	82	210.13		

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Male)	49	77.43	15.03
2: (Female)	34	73.97	13.64

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	30	78.97	13.40
2: (Non-Participants)	53	74.34	14.94

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Male Part.)	15	81.33	14.97
1 & 2: (Male Non-Part.)	34	75.71	14.96
2 & 1: (Female Part.)	15	76.60	11.66
2 & 2: (Female Non-Part.)	19	71.89	15.01

Comparison of First-Time and Course Repeating, Participants and Non-Participants - Test #2

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	111.10	1	111.10	0.53	0.4677
Columns	410.13	1	410.13	1.97	0.1648
Interaction	225.59	1	225.59	1.08	0.3016
Error	16484.16	79	208.66		
Total	17230.99	82	210.13		

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (First-Time)	48	77.00	15.60
2: (Repeating)	35	74.66	12.92

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	30	78.97	13.40
2: (Non-Participants)	53	74.34	14.94

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (First-Time Part.)	20	81.30	13.95
1 & 2: (First-Time Non-Part.)	28	73.93	16.23
2 & 1: (Repeating Part.)	10	74.30	11.47
2 & 2: (Repeating Non-Part.)	25	74.80	13.68

Comparison of Traditional and Non-Traditional, Participants and Non-Participants - Test #2

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	431.49	1	431.49	2.11	0.1506
Columns	410.13	1	410.13	2.00	0.1610
Interaction	0.00	0	0.00	0.00	1.0000
Error	16389.36	80	204.87		
Total	17230.99	82	210.13		

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Traditional)	68	74.94	14.94
2: (Non-Traditional)	15	80.87	11.46

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	30	78.97	13.40
2: (Non-Participants)	53	74.34	14.94

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Trad. Part.)	20	77.00	14.57
1 & 2: (Trad. Non-Part.)	48	74.08	15.16
2 & 1: (Non-Trad. Part.)	10	82.90	10.24
2 & 2: (Non-Trad. Non-Part.)	5	76.80	13.90

Unit 3 Supplemental Instruction Test Statistics

Comparison of Participants and Non-Participants - Test #3

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	1857.34	1	1857.34	3.4454*	0.0675
Within	39352.98	73	539.08		
Total	41210.32	74			

* p < .10 Does not meet the level required for this study

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	35	69.00	20.71
2 - Non-Participants	40	59.03	25.20

Comparison of Low, Medium, and High Attenders - Test #3

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	2798.46	2	1399.23	3.7998**	0.0331
Within	11783.54	32	368.24		
Total	14582.00	34			

** p < .05

Group	*N*	*Mean*	*Std. Dev.*
1 - Low Attenders	23	62.70	20.92
2 - Medium Attenders	3	75.33	27.06
3 - High Attenders	9	83.00	9.29

Comparison of Male and Female, Participants and Non-Participants - Test #3

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	413.64	1	413.64	0.76	0.3875
Columns	1820.29	1	1820.29	3.33*	0.0724
Interaction	286.38	1	286.38	0.52	0.4717
Error	38844.36	71	547.10		
Total	41364.67	74	558.98		

* $p < .10$ Does not meet level required for this study

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Male)	44	65.70	21.16
2: (Female)	31	60.94	26.90

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	35	69.00	20.71
2: (Non-Participant)	40	59.13	25.30

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Male Part.)	18	72.00	20.31
1 & 2: (Male Non-Part.)	26	61.35	21.00
2 & 1: (Female Part.)	17	65.82	21.26
2 & 2: (Female Non-Part.)	14	55.00	32.31

Comparison of First-Time and Course Repeating, Participants and Non-Participants - Test #3

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	762.68	1	762.68	1.42	0.2380
Columns	1820.29	1	1820.29	3.38*	0.0701
Interaction	0.00	0	0.00	0.00	1.0000
Error	38781.70	72	538.63		
Total	41364.67	74	558.98		

* $p < .10$ Does not meet the level required for this study

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (First-Time)	48	66.13	24.10
2: (Repeating)	27	59.48	22.61

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	35	69.00	20.71
2: (Non-Participants)	40	59.13	25.30

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (First-Time Part.)	26	71.73	20.86
1 & 2: (First-Time Non-Part.)	22	59.50	26.41
2 & 1: (Repeating Part.)	9	61.11	19.21
2 & 2: (Repeating Non-Part.)	18	58.67	24.62

Comparison of Traditional and Non-Traditional, Participants and Non-Participants - Test #3

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	256.42	1	256.42	0.47	0.4942
Columns	1857.34	1	1857.34	3.42*	0.0685
Interaction	0.00	0	0.00	0.00	1.0000
Error	39096.56	72	543.01		
Total	41210.32	74	556.90		

* $p < .10$ Does not meet the level required for this study

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Traditional)	63	62.87	23.83
2: (Non-Traditional)	12	67.92	22.83

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	35	69.00	20.71
2: (Non-Paticipant)	40	59.03	25.20

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Trad. Part.)	24	69.17	19.69
1 & 2: (Trad. Non-Part.)	39	59.00	25.53
2 & 1: (Non-Trad. Part.)	11	68.64	23.80
2 & 2: (Non-Trad. Non-Part.)	1	60.00	0.00

Unit 4 Supplemental Instruction Test Statistics

Comparison of Participants and Non-Participants - Test #4

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	16167.73	1	16167.73	43.8327***	0.0001
Within	25819.59	70	368.85		
Total	41987.32	71			

*** $p<.01$

Group	*N*	*Mean*	*Std. Dev.*
1 - Participant	30	84.13	12.72
2 - Non-Participant	42	53.74	22.70

Comparison of Low, Medium, and High Attenders - Test #4

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	1147.22	2	573.61	4.3697**	0.0227
Within	3544.25	27	131.27		
Total	4691.47	29			

** $p<.05$

Group	*N*	*Mean*	*Std. Dev.*
1 - Low Attenders	15	78.33	10.21
2 - Medium Attenders	12	88.42	13.45
3 - High Attenders	3	96.00	6.93

Comparison of Male and Female, Participants and Non-Participants - Test #4

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	45.07	1	45.07	0.13	0.7217
Columns	16167.73	1	16167.73	45.91***	0.0001
Interaction	1826.53	1	1826.53	5.19**	0.0259
Error	23947.99	68	352.18		
Total	41987.32	71	591.37		

** p < .05 *** p < .01

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Male)	42	67.07	23.51
2: (Female)	30	65.47	25.78

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	30	84.13	12.72
2: (Non-Participant)	42	53.74	22.70

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Male Part.)	13	87.62	11.35
1 & 2: (Male Non-Part.)	29	57.86	21.69
2 & 1: (Female Part.)	17	81.47	13.39
2 & 2: (Female Non-Part.)	13	44.54	23.02

Comparison of First-Time and Course Repeating, Participants and Non-Participants - Test #4

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	84.53	1	84.53	0.22	0.6372
Columns	16167.73	1	16167.73	42.92***	0.0001
Interaction	120.11	1	120.11	0.32	0.5742
Error	25614.95	68	376.69		
Total	41987.32	71	591.37		

*** $p < .01$

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (First-Time)	46	67.22	25.78
2: (Repeating)	26	64.96	21.91

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participants)	30	84.13	12.72
2: (Non-Participants)	42	53.74	22.70

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (First-Time Part.)	22	84.00	13.09
1 & 2: (First-Time Non-Part.)	24	51.83	25.04
2 & 1: (Repeating Part.)	8	84.50	12.49
2 & 2: (Repeating Non-Part.)	18	56.28	19.56

Comparison of Traditional and Non-Traditional, Participants and Non-Participants - Test #4

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	2511.29	1	2511.29	8.04***	0.0060
Columns	15704.99	1	15704.99	50.26***	0.0001
Interaction	0.00	0	0.00	0.00	1.0000
Error	21247.15	68	312.46		
Total	39463.44	70	563.76		

*** $p < .01$

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Traditional)	60	64.20	23.61
2: (Non-Traditional)	11	80.64	20.17

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	30	84.13	12.72
2: (Non-Participant)	41	54.02	21.83

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Trad. Part.)	21	83.10	10.85
1 & 2: (Trad. Non-Part.)	39	54.03	22.36
2 & 1: (Non-Trad. Part.)	9	86.56	16.82
2 & 2: (Non-Trad. Non-Part.)	2	54.00	8.49

Unit 5 Supplemental Instruction Test Statistics

Comparison of Participants and Non-Participants - Test #5

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	3328.87	1	3328.87	8.9568***	0.0040
Within	22299.52	60	371.66		
Total	25628.39	61			

*** $p < .01$

Group	*N*	*Mean*	*Std. Dev.*
1 - Participants	33	83.03	15.87
2 - Non-Participants	29	68.34	22.55

Comparison of Low, Medium, and High Attenders - Test #5

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	1080.26	2	540.13	2.3206	0.1156
Within	6982.71	30	232.76		
Total	8062.97				

Group	*N*	*Mean*	*Std. Dev.*
1 - Low Attenders	15	84.60	10.06
2 - Medium Attenders	9	74.22	22.91
3 - High Attenders	9	89.22	13.07

Comparison of Male and Female, Participants and Non-Participants - Test #5

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	246.45	1	246.45	0.68	0.4114
Columns	3328.87	1	3328.87	9.25***	0.0035
Interaction	1173.73	1	1173.73	3.26*	0.0762
Error	20879.34	58	359.99		
Total	25628.39	61	420.14		

*** p <.01 * p < .10 Does not meet level required

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Male)	34	77.97	18.88
2: (Female)	28	73.96	22.46

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	33	83.03	15.87
2: (Non-Participant)	29	68.34	22.55

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Male Part.)	17	81.82	19.64
1 & 2: (Male Non-Part.)	17	74.12	17.84
2 & 1: (Female Part.)	16	84.31	11.07
2 & 2: (Female Non-Part.)	12	60.17	26.59

Comparison of First-Time and Course Repeating, Participants and Non-Participants - Test #5

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	68.57	1	68.57	0.18	0.6733
Columns	3309.09	1	3309.09	8.67***	0.0047
Interaction	467.79	1	467.79	1.23	0.2729
Error	21755.86	57	381.68		
Total	25601.31	60	426.69		

*** $p < .01$

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (First-Time)	38	75.42	23.12
2: (Repeating)	23	77.61	16.19

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	33	83.03	15.87
2: (Non-Participant)	28	68.25	22.96

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (First-Time Part.)	23	82.74	17.73
1 & 2: (First-Time Non-Part.)	15	64.20	26.37
2 & 1: (Repeating Part.)	10	83.70	11.27
2 & 2: (Repeating Non-Part.)	13	72.92	18.17

Comparison of Traditional and Non-Traditional, Participants and Non-Participants - Test #5

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	1599.86	1	1559.86	4.44**	0.0394
Columns	3328.87	1	3328.87	9.47***	0.0032
Interaction	0.00	0	0.00	0.00	1.0000
Error	20739.66	59	351.52		
Total	25628.39	61	420.14		

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

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Traditional)	53	74.09	21.20
2: (Non-Traditional)	9	88.33	9.38

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	33	83.03	15.87
2: (Non-Participant)	29	68.34	22.55

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Trad. Part)	24	81.04	17.46
1 & 2: (Trad. Non-Part.)	29	68.34	22.55
2 & 1: (Non-Trad. Part.)	9	88.33	9.38
2 & 2: (Non-Trad. Non-Part.)	0	0.00	0.00

Final Exam Supplemental Instruction Test Statistics

Comparison of Participants and Non-Participants - Final Exam

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	3640.08	1	3640.08	9.4059***	0.0035
Within	18575.92	48	387.00		
Total	22216.00	49			

*** $p<.01$

Group	*N*	*Mean*	*Std. Dev.*
1 - Participant	30	68.77	17.41
2 - Non-Participant	20	51.35	22.69

Comparison of Low, Medium, and High Attenders - Final Exam

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Among	1213.47	2	606.74	2.4102	0.1038
Within	9314.30	37	251.74		
Total	10527.78	39			

Group	*N*	*Mean*	*Std. Dev.*
1 - Low Attenders	26	65.23	16.23
2 - Medium Attenders	9	68.89	13.69
3 - High Attenders	5	82.20	17.51

Comparison of Male and Female, Participants and Non-Participants

Final Exam

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	494.00	1	494.00	1.44	0.2350
Columns	3628.66	1	3628.66	10.57***	0.0019
Interaction	215.30	1	215.30	0.63	0.4315
Error	21294.48	62	343.46		
Total	25632.44	65	394.35		

*** P < .01

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Male)	36	64.69	19.31
2: (Female)	30	59.20	20.42

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	40	68.18	16.43
2: (Non-Participant)	26	53.00	21.43

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Male Part.)	21	70.38	15.44
1 & 2: (Male Non-Part.)	15	56.73	21.79
2 & 1: (Female Part.)	19	65.74	17.55
2 & 2: (Female Non-Part.)	11	47.91	20.82

Comparison of First-Time and Course Repeating, Participants and Non-Participants - Final Exam

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	741.88	1	741.88	2.20	0.1432
Columns	3628.66	1	3628.66	10.75***	0.0017
Interaction	0.00	0	0.00	0.00	1.0000
Error	21261.90	63	337.49		
Total	25632.44	65	394.35		

*** $p < .01$

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (First-Time)	40	64.90	20.36
2: (Repeating)	26	58.04	18.68

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	40	68.18	16.43
2: (Non-Participant)	26	53.00	21.43

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (First-Time Part.)	29	69.52	17.54
1 & 2: (First-Time Non-Part.)	11	52.73	23.05
2 & 1: (Repeating Part.)	11	64.64	13.14
2 & 2: (Repeating Non-Part.)	15	53.20	20.98

Comparison of Traditional and Non-Traditional, Participants and Non-Participants - Final Exam

Source	*Sum of Sqr.*	*DF*	*Var. Est.*	*F-Ratio*	*Prob. F*
Rows	595.13	1	595.13	1.56	0.2185
Columns	3640.08	1	3640.08	9.51***	0.0034
Interaction	0.00	0	0.00	0.00	1.0000
Error	17980.79	47	382.57		
Total	22216.00	49	453.39		

*** $p < .01$

Row Var.	*N*	*Mean*	*Std. Dev.*
1: (Traditional)	40	60.08	20.70
2: (Non-Traditional)	10	68.70	23.37

Column Var.	*N*	*Mean*	*Std. Dev.*
1: (Participant)	30	68.77	17.41
2: (Non-Participant)	20	51.35	22.69

Combination	*N*	*Mean*	*Std. Dev.*
1 & 1: (Trad. Part.)	20	68.80	14.29
1 & 2: (Trad. Non-Part.)	20	51.35	22.69
2 & 1: (Non-Trad. Part.)	10	68.70	23.37
2 & 2: (Non-Trad. Non-Part.)	0	0.00	0.00

Initial Class Survey

1. To what degree do students in general seek help?

Not at all	0.0%
Very little	32.1%
About half the time	67.0%
Most of the time	0.9%

2. How often do you seek help?

Never	0.1%
Sometimes	56.8%
Most of the time	33.9%
Always	9.2%

3. What source do you primarily use for help?

Friends/peers	51.9%
Professors	40.1%
Adult advisor	4.3%
Other	3.7%

4. To what degree can students affect their own achievement?

None	0.0%
Very little	2.7%
To a large degree	39.1%
Almost totally	58.2%

5. What level of change do you foresee in your own enlistment of assistance?

None	8.2%
Some	41.3%
Much	50.5%

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