EVALUATING THE EFFECTIVENESS OF A LEARNING SYSTEM FOR TECHNICAL CALCULUS

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

In 1986, 1.8 million of the 2.8 million students who entered college for the first time ended up leaving the first institution that they attended without earning a degree (Tinto, 1987). Colleges and universities continue to develop programs to help retain students, however, Siedman (2005) states that recent retention data reveals that today's students are not being retained in colleges and universities at a higher rate than the retention rate that Tinto reported in 1986. Many students that enter college are not prepared for the responsibility of college life and the demands of college level courses. Gunawardena states that "students who enter college are often under prepared and lack the background and motivation to succeed in college-level mathematics" (p.108). Ainsworth (1994) argues that students who come to college without an adequate background in math will likely withdraw from or quit performing when a math class becomes difficult. Students who are under prepared and even those who are adequately prepared, fail to be successful because the class becomes difficult in their eyes and they don't believe that they can be successful.

Calculus is a subject that students struggle with and is one of the most difficult subjects in college because it "is a coherent theory that builds on all of high school mathematics and then builds on itself. That is, one must thoroughly understand what has come before in order to go on" (Douglas, 1985). Since calculus builds on what has come before, many students who have struggled with algebra and trigonometry will struggle with calculus. If students have an inadequate background in algebra, then troubles will usually emerge as they progress through the course, and it is their responsibility to find resources to help them learn the material. They can find resources such as the professor's office hours, study groups, tutors, friends, classmates, academic centers, and math help centers. In addition, there are many other free resources that are on the internet. For example, you can find all of these great study aides on the internet: java applets on math topics, videos of course-content provided through Windows Media Player, Power Point slides of math lessons, and assistance using mathematical programs like Maple or Mathematica. The internet has allowed many of these resources to be accessible by students all over the world.

The calculus reform movement was one of the first movements that began to question how calculus had been taught for years in college and whether calculus was meeting the needs of its audience. The calculus reform movement, which began in the early 1980's, did not attempt to challenge the content of calculus, but to examine the way calculus was being taught (Long, 2004). The beginning of the movement was concerned with changing calculus from being a filter for the further study of math, science, and engineering, to being a pump for those fields. Long (2004) stated that calculus was "the one class that seemed to be making or breaking students in mathematics and science" (p. 3). The calculus reform movement tried to enhance the way students learned mathematics by using pedagogical techniques that were radically different from the norm of how calculus had been taught in the past (Long, 2004).

Marcoff, cited by Douglas in The Importance of Calculus in Core Mathematics, stated "calculus cannot be learned passively. As the subject builds, the student must continually master ideas and techniques in order to profitably continue" (Marcoff, 1985). The National Council of Teachers of Mathematics (NCTM) state in Professional Standards for Teaching Mathematics, that "when students learn from the experience of doing, they are much more likely to retain and use what they have learned" (NCTM, 1991, p. 3). Furthermore, NCTM states "student's learning of mathematics is enhanced in a learning environment that is built as a community of people collaborating to make sense of mathematical ideas. It is a key function of the teacher to develop and nurture students' abilities to learn with and from others" (p. 58). Moving Beyond Myths: Revitalizing Undergraduate Mathematics (1991) recommends that instructors "explore effective alternatives to 'lecture and listen'" and "involve students actively in the learning process" (p. 34). There is something about being actively involved that engraves things into the minds of students.

"Each mathematics instructor must find his or her own means of getting students involved in the learning process, of helping them to become educated" (Krantz, 1999). Instructors might find that group work or other instructional tools developed using various technologies, could enable their students to get more involved in the learning process and to understand the course material better. Krantz questions the reader in You Don't Need a Weatherman to Know Which Way the Wind Blows, "couldn't well-constructed computer labs bridge this gap, and help students of average ability to understand why and how mathematics works?" (1991, p. 916). His question could also be asked of other instructional tools or group learning instead of only mentioning computer labs in helping students 'discover' mathematics. He continues with "students might discuss and collaborate profitably if (computer-aide) material is put before them that will stimulate such interaction" (1991, p. 916); that will allow students to make mathematical discoveries when the designed activities lead him or her to it (Krantz, p. 916). In Lecturing at the "Bored", Wahlberg asks the reader, "what is it that keeps me at the board, telling my students about mathematics, with seamless lectures and well-chosen examples?" (1997, p. 552). This question is in reflection after she had finished teaching a calculus course one semester. During the semester she did not lecture, but had the class work as one large cooperative group where she presented examples and the students worked open-ended questions. She states that this enabled students to become more actively engaged in the learning process and the students complained when she tried to lecture over the fundamental theorem of calculus later in the semester.

The researcher helped create an online learning supplement and used discussion sessions to help students to be more successful and to become more actively involved in their own learning in a technical calculus. The underlying goal of this study is to see how and why students used the online learning supplement. It was easy to put counters on the webpage to see how often it was used, but no information was being obtained on why students were using the supplement or what type of help students were receiving when they used it. Also it was going to be challenging to get accurate data on why or what was students' motivation for using the supplement from a questionnaire. In order to get different information, a qualitative study was needed. After looking at research on supplemental instruction, which will be defined on page 22, the study was enlarged to look at a Supplemental Instruction (SI) like structure by adding discussion sessions. In this view the online learning supplement could also be viewed as an online SI. This addition not only enlarged the study but it also gave a large collection of participants that could be studied for the entire semester. The decision to include discussion sessions in the study made it impossible to determine if any of the differences in grades were the result of the use of the discussion sessions or the online learning supplement.

In addition to the qualitative data, some quantitative data was also collected concerning attendance, course grades, and a questionnaire that had both qualitative and quantitative portions. This allowed the researcher to collect information on participants and non-participants that pertained to the course and the TCLS and discussion sessions.

The study is being considered as a type of SI; so its results contribute to the large collection of literature on SI, but they also answer some practical questions such as which parts of the TCLS do students use and why and how are they using them. This information can be helpful to instructors who are designing similar types of help materials for the web as well as to designers of web-based courses. Furthermore, instructors of online courses that are searching for ways to help their students might find this information helpful in designing materials.

Background of the Problem

Success and Nonsuccess in Technical Calculus

Success in mathematics is not just for the gifted, most talented math student. “Many people assume that it takes a special kind of brain to be able to do mathematics – that unless you were born with some kind of ‘math gene,’ you simply are not going to be able to get math, no matter how hard you try” (Devlin, 2000, p. 1). In Moving Beyond

Myths: Revitalizing Undergraduate Mathematics (1991), we see that a common myth in school and society is that “success in mathematics depends more on innate ability than hard work” (p. 10) Commonly teachers hear students say, among other things, “they are not good at math,” “they have never been able to learn mathematics,” and “math is not for them.” Students’ fear of mathematics and the belief that they can’t learn mathematics is reinforced by parents that say that they could not learn mathematics. “One thing that may contribute to a student’s passivity towards math is a common myth about mathematical ability. Most of us believe that people either have or do not have a mathematical mind” (Tobias, 1978, p.46). The way to learn mathematics is not by being a passive student, but by working diligently on mathematics each week. As the authors of *In Moving Beyond Myths* suggest;

> A sustained effort can carry most students to a satisfactory level of achievement in mathematics. Compare music and mathematics: although in both areas genetic factors clearly play a role at the very highest levels of creative achievement, parents and teachers generally believe that children can learn to play music at a reasonable level if only they exert sufficient effort. As a consequence, many students achieve success and personal satisfaction from their study of music. Whenever parents or teachers believe that genetic ability is the primary factor contributing to success in mathematics, students are likely to fail before they begin; when expectations of success are high, so is the resulting performance (Moving Beyond Myths, 1991, p. 10-11).

The study of mathematics, like the study of music, takes time and effort to master; it is not simply a matter of “natural” genius.

The National Council on Teaching Mathematics and Burmeister view mathematics as a subject that takes time and repetition to master, no matter what mathematical topic you are studying. In particular, the National Council on Teaching Mathematics' (NCTM's) Curriculum Standards for Teaching Mathematics, states that "to learn mathematics, students must be engaged in exploring, conjecturing, and thinking. When students learn from the experience of doing, they are much more likely to retain and use what they have learned" (1989, p. 3). In other words, "success in mathematics requires daily practice and analysis, much like the repetitive work required to master a foreign language" (Burmeister, 1994, Winter, p. 53). Furthermore, "what students learn is fundamentally connected with how they learn it" (NCTM, 1989, p. 6).

Students who come to college without an adequate background in math will likely withdraw from or quit performing when a math class becomes difficult (Ainsworth, 1994). This statement fits technical calculus students well and is consistent with the success rates for large university calculus courses in general, where less than half of the students that start the semester enrolled in calculus finish the term with passing grades (Steen; 1987, p. 17). Table 1 below shows the D-F-W rate for the last fifteen semesters of technical calculus at the University where the research was conducted, where the average D-F-W rate during these fifteen semesters is 42.95% with a standard error of 1.38%. From spring 2002 to fall 2005, the D-F-W rate for college algebra and engineering calculus I, were 36.6% and 45.1%, respectively. To determine if the D-F-W rate for technical calculus was significantly different than the D-F-W rate for calculus, the researcher performed a two tailed t-test and determined that there is no significant difference ($p=0.1220$) between the D-F-W rates for the two classes. In addition, the researcher performed a two tailed t-test to determine if the D-F-W rate of technical calculus was significantly different than the D-F-W rate for college algebra and determined that the D-F-W rate for technical calculus is significantly different than the D-F-W rate for college algebra (p=0.00008) at $\alpha = 0.001$ level.

Table I

D-F-W Rate for Technical Calculus for the Past 15 semesters

Semester	S98	F98	S99	F99	S00	F00	S01	F01	S02	F02	S03	F03	S04	F04	S05
D-F-W Rate (%)	60.7	43.6	24.1	34	43.8	31.3	52.6	33.7	50	47.4	59.5	36.7	40	48.2	38.6

In Table 1, we see that the D-F-W rate has varied from 24.1% to 60.7% during the past 15 semesters. We can see clearly that students have had difficulty being successful in technical calculus. The researcher has spent time teaching the course, beginning in the fall 1999 with two classes and one class during the spring 2002 semester. What are the reasons that almost half of the students enrolling in technical calculus for the past 15 semesters are not successfully completing the course with a grade of a C or better? The researcher spent 5 semesters from spring 2000 to fall 2001, and spring 2003, teaching technical calculus II. This wealth of experience has given the researcher first-hand experience with students in technical calculus, and in particular, the researcher believes it is the student's lack of algebra skills that are causing them so much trouble.

Lecture Method and Collaborative Learning

Technical Calculus is taught using the following method: the instructor lectures about the concepts, and students work on problems by themselves or with others outside of class time. Students sit in class passively while the instructor lectures, believing that they understand the material better than they do. However, when they try to work the problems outside of class some of them have trouble knowing how to work the problems. One way that students can actively participate in a class is through collaborative learning. We will look more closely at the lecture method and collaborative learning in the next few paragraphs.

The lecture method remains one of the most common instructional methods in secondary schools (Newton, 1982; Johnson, Johnson, and Smith, 1991). Not only do schools use the lecture method, lecturing is the most predominate way of presenting information in colleges and universities (Johnson, Johnson, Smith, 1991). Some teachers have looked at students as a blank sheet of paper on which the professor writes, or as an empty vessel, which the professor fills with his or her wisdom (Johnson, Johnson, Smith, 1991). NCTM's Professional Standards for Teaching Mathematics (1991) states that the teaching practice in schools should change from a lecture instruction format to a format that actively engages students in the learning process. Newton states that in order for the lecture method to be successful, the student should show the readiness of the following:

> (1) the ability to focus on the business-at-hand through consciously screening-out unrelated distractions; (2) skill in 'active,' 'reconstructive' listening – i.e., alertly decoding the lecturer's expressed ideas through associating, relating, accepting, rejecting, analyzing, speculating, and connecting them to previously learned materials; (3) writing in note form (i.e. abbreviated clause, phrases, key-words) the dominant ideas and most important facts; (4) translating and converting the information and (5) systematically and periodically modifying, amending, reviewing, and

> synthesizing lecture notes for reinforcement, reorganization, and recategorization into the larger context as the course develops (1982, p. 20).

The lecture method could also clash with the instructional method used in classes in their major. Newton states that

> in land-grant-state institutions of higher education, the fields of agriculture, engineering, and applied sciences have clearly identifiable goals to which the courses of studies relate directly. These studies usually involve considerable student activity in the laboratory, or in the field, apprenticeship, work-study, demonstration, or internship programs. Both on and off the campus, these various types of hands-on, direct-exposure learning experiences contribute largely to the attainment of course and student objectives. The instructional systems in these fields of study, therefore, generally meet the needs of the heterogeneous student populations in land-grant-state institutions with greater success than do studies in the arts and sciences disciplines in these colleges (1982, p. 26).

Newton continues to state that the lecture method is used in colleges and divisions of arts and sciences in land-grant-state institutions of higher education and "it is probable that the most effective teaching-learning procedures in land-grant-state institutions occur in the agricultural-engineering-applied sciences divisions" (1982, p. 25).

Definitely the lecture method is the method of choice for most instructors when presenting the topics in technical calculus. Occasionally the instructors will use groups to work on example problems or quizzes, but more commonly they present material through lecture. This lecture method could clash with the instructional method that the majority of students in technical calculus are used to, and hence might be one of the reasons why students have difficulty with the course. They are more familiar with hands-on, direct exposure, or other active methods of attaining the course objectives for their required courses. To sum this all up, some of the courses that technical calculus students take that pertain to their major are courses that use different methods, courses in which students are either actively learning in a laboratory with hands on experiences, or learning by watching the instructor demonstrate on some particular equipment or device. This is not to say that these students do not see lecture methods at all in their major classes, but it does say that instructors will use a variety of different active instructional methods along with the traditional lecture method.

Collaborative learning is a method used in instruction that is different than the lecture method and actively involves students in their learning. “Collaborative learning represents a significant shift away from the typical teacher-centered or lecture-centered milieu in college” (Smith and MacGregor, 1992, p. 9). Smith and MacGregor state that “collaborative learning holds enormous promise for improving student learning and revitalizing college teaching” (Smith and MacGregor, 1992, p. 9). Webster’s dictionary definition of collaborative is “working together, especially in a joint intellectual effort.” Gerlach states that collaborative learning is “based on the idea that learning is a naturally social act in which the participants talk among themselves” (Gerlach, 1994, p. 8), and Saltiel gives a similar definition by stating “collaborative learning is students working together to construct knowledge” (Saltiel, 1998, p.7). Smith and MacGregor give a more general definition of collaborative learning, stating that collaborative learning is an umbrella term that "describes the many educational approaches involving 'joint intellectual effort'" (Smith and MacGregor, 1992, p.10).

Collaborative learning assumes the following about learners and the learning process (Smith and MacGregor, 1992, p. 10-11; Gerlach, 1994, p.8-9):

1. Learning is an active, constructive process
2. Learning depends on rich contexts
3. Learners are diverse and have different backgrounds and experiences
4. Learning is a social act in which students talk to learn
5. Learners engage in higher-order reasoning and problem solving skills
6. Learning has affective and subjective dimensions

Collaborative learning has been used more extensively in primary and secondary school settings (Haring-Smith, 1993) than in college (Gerlach, 1994). In addition, the more a child progresses in their primary and secondary education, the less they experience school work that incorporates collaborative or group learning (Haring-Smith, 1993). Furthermore, the majority of the research on collaborative learning has been in primary and secondary school settings (Gerlach, 1994; Smith and MacGregor, 1992).

The isolated learning that exists in schooling is not in step with the way things are accomplished in the real world. "If people outside school were punished for collaborating, most of our society would be paying fines every day" (Haring-Smith, 1993, p. 2). Using collaborative learning structure in classroom will teach students to work with other people more in the sense of what they will experience in their future jobs.

Collaborative learning is an instructional method in which students become more actively involved in their own learning (Gerlach, 1994; Saltiel, 1998; Johnson, Johnson, Smith, 1991; Haring-Smith, 1993; Smith and MacGregor, 1992; Bruffee, 1992; Flannery, 1994) and work with others. According to Flannery (1994), students are more likely to learn subject matter that they are actively involved in learning.

Research on collaborative learning has shown that it promotes active learning (Hamm and Adams; 1992) and increases academic performance (Gerlach, 1994). It helps students to reach a deeper understanding of the course material (Gerlach, 1994) and learn for themselves (Haring-Smith, 1993). In addition, students are more likely to remember what they learned and to spend time putting material into their own language or teaching it to others (Haring-Smith, 1993).Collaborative learning "works by finding out what you know and then allowing the teacher to respond and give you exercises that will let you learn" (Haring-Smith, 1993, p. 6), and sharpens the students skills. Finally, "collaborative learning leads students to become much more directly immersed in the ideas of the class" (Smith and MacGregor, 1992).

Supplemental Instruction is one of many learning systems that uses a collaborative learning structure in which a supplemental instruction leader facilitates the voluntary group of students in learning material for the course through various group activities (Martin and Wilcox, 1996; Marin and Blanc, 1994; SI staff, 1997; Arendale, 1998; Martin and Arendale, 1993; Martin, Blanc, and Arendale, 1996; Arendale, 1993; Hodges, 2001; Visor, Johnson, and Cole, 1992). The research on supplemental instruction has shown that student's academic performance increases (Martin and Wilcox, 1996; SI staff, 1997; Arendale, 1998; Martin, Blanc, and Arendale, 1996; Arendale, 1993; Smuts, 1997; Congos, 1993;Blanc, DeBuhr, and Martin, 1983; Visor, Johnson, and Cole, 1992; Ogden, Thompson, Russell, and Simons, 2003; Arendale 1994), no matter what the student's background, ethnicity, or prior academic background (SI staff,1997; Arendale, 1998; Smuts, 1997; Congos 1993), and that this method increases student retention (Martin and Wilcox, 1996; SI staff 1997; Arendale, 1998; Martin, Blanc, and Arendale, 1996; Arendale, 1993; Smuts, 1997;Blanc, DeBuhr, and Martin, 1983;Visor, Johnson, and Cole, 1992;Ogden, Thompson, Russell, and Simons, 2003; Widmar, 1994; Arendale, 1994). The researcher will review the literature on supplemental instruction and collaborative and cooperative group learning in the next chapter.

Statement of the Problem

In 2001, the researcher, with the help and guidance of Dr. Doug Aichele, designed and wrote the materials for the online Technical Calculus Learning Supplement (TCLS). These materials are located on the Technical Calculus Learning Supplement website, at www.math.okstate.edu/~millerd/TCLS.html. The website was designed to assist technical calculus students in learning the course material and to help students be more successful in completing the course. It was evident, through a counter that was placed on the website, that some students were using it. However, the researcher did not know which students were using the online learning supplement, when they were using the supplement, how they were using it, what kind of help they were getting from it, nor what their perceptions were about the online learning supplement.

To help increase the number of students who use the TCLS, the researcher decided to implement voluntary discussion sessions and use the TCLS for reference during each discussion session. The idea for the discussion session came from the research in supplemental instruction.

The majority of the research in supplemental instruction has employed a quantitative research design. The nature of the research questions being asked in this research study makes it difficult to answer the majority of the research questions using only a quantitative research design. Therefore the researcher employed a qualitative research design to collect data and analyze the majority of research questions. However, the researcher did use quantitative research methods to collect and analyze data on a few of the research questions.

Purpose of the Study

The purpose of this study is to describe students' experiences and perceptions of the technical calculus learning supplement and the voluntarily discussion sessions. In addition, this study will examine how and when the technical calculus learning supplement was used during the course of the semester and compare the algebra skills for the participants and non-participants in the study. Results of this research contribute to literature on supplemental instruction, more specifically to the literature on supplemental instruction for a calculus course. In addition, this research will add to the literature on qualitative analysis dealing with mathematics. Furthermore, the results of the research will help the researcher understand in what ways the learning supplement helps students with technical calculus. The answers to the research questions will help the researcher design a better learning supplement for different classes in the future and in particular, design instructional tools that will help students understand course material better and help them be more successful in the course in which they are enrolled in. The following research questions were addressed during the course of the study:

i. What are the experiences of technical calculus students with the Technical Calculus Learning Supplement (TCLS)?

   (a) What components of the TCLS do students use and why do they use those components?

   (b) What components of the TCLS do students not pay particular attention to and why do they not use them?

   (c) How do students use the components of the TCLS? (Are students using it the way it was intended it to be used?)

ii. What are the students' perceptions of the TCLS?

   (a) What are the students' perceptions on how the TCLS helps them in the course?

   (b) How much of their success do students attribute to the TCLS?

   (c) What is the students' overall opinion of the TCLS?

iii. What are the experiences of technical calculus students with the discussion sessions?

   (a) What are the reasons students attend or do not attend the discussion sessions?

   (b) Are most of the students who attend the discussion sessions also students who attend the class regularly?

iv. What are the students' perceptions with respect to the group sessions?

(a) To what extent do students attribute their success in the course to the discussion sessions?

(b) What are the students' perceptions of the three-step method structure of the discussion sessions?

(c) What are student's overall opinions of the discussion sessions?

v. How do the course grades and the pre and post-algebra assessment scores for those students who attend the discussion sessions and use the TCLS compare to students who do not attend the discussion sessions?

vi. When do the students use the TCLS?

(This gives input to the motivation for use of the TCLS and could be measured by a weekly monitoring of the counters on the website, as well as by interviewing.)

vii. Are there parts of the TCLS that should be expanded and/or deleted?

(Information will be gathered about this question in the following ways: 1) through the counters on the website, 2) through the long interviews, and 3) during informal conversations with the students during the discussion sessions.)

viii. Should there be any improvements to the TCLS to better help students with technical calculus?

Ultimately, the researcher hopes that this study will not only add to the current research, but shall demonstrate that varying supplemental instruction so that it helps students be more active and gain more independence by working in groups is very beneficial. Finally, many students who take mathematics classes have a negative viewpoint of mathematics and it is the researcher's hope that this learning supplement, in a small way, might positively change students' viewpoints of mathematics.

We will now look at the assumptions and limitations for this study, and the definitions of terms used in this study. We will end this chapter with the organization of the study.

Assumptions

1. Each participant will be thoughtful and respond honestly to each interview question during the end of the semester interview.
2. Each student will fill out all questionnaires honestly and completely.
3. The algebra assessment is an accurate measure of each student's algebra knowledge.

Limitations

1. The discussion sessions will be led by a graduate student with 10 years experience and approximately 3 years experience teaching technical calculus I and technical calculus II. Therefore, this type of research design might be harder to replicate with an undergraduate as the leader of the discussion sessions. The usual practice in SI is to use an undergraduate as the discussion leader.
2. The discussion sessions were structured using the three step method. The researcher would start the sessions with an example from the online learning supplement (step 1), followed by another example in which the researcher solicited help from the students in attendance (step 2), and then followed by the researcher giving the students problems to work by themselves or in small groups

(step 3). Sessions less structured might not result in the same outcome as that of the more structured sessions.

3. The participants of this study are primarily majoring in fire protection, construction management, electrical engineering technology, and mechanical engineering technology. This study might not have the same results if replicated for other student populations.

The researcher now will go over definitions that are used throughout the rest of this paper.

Definition of Terms

Construction Management Technology, (CMT). An OSU degree program offered through the Division of Engineering Technology in the College of Architecture, Engineering, and Technology. Students completing this program are preparing for careers in the construction industry.

Electrical Engineering Technology, (EET). An OSU degree program offered through the Division of Engineering Technology in the College of Architecture, Engineering, and Technology. Students completing this program are preparing for careers such as customer service representatives, plant managers, system designers, computer programmers, and electronic designers (EET history of the program website – http://techweb.ceat.okstate.edu/eet/).

Fire Protection and Safety, (FPST). An OSU degree program offered through the Division of Engineering Technology in the College of Architecture, Engineering, and Technology. Students completing this program are preparing for careers in Loss Control.

The loss control profession is segmented into three major areas: loss from fire, loss from physical accident, and loss from environmental exposure (FPST The Program website : http://fpst.okstate.edu/curriculum.html).

Mechanical Engineering Technology, (MET). An OSU degree program offered through the Division of Engineering Technology in the College of Architecture, Engineering, and Technology. Students who our majoring in MET are emphasizing in computer aided drafting and solid modeling, fluid power (hydraulics, pneumatics, electronic control), applied engineering analysis, and manufacturing and materials. Students completing this program are preparing for employment within industry's engineering team (MET Program Description website – http://techweb.ceat.okstate.edu/met/).

MLRC. Mathematics Learning Resource Center helps students with mathematics classes from intermediate algebra through linear algebra. In addition, the MLRC has computers and video tapes available to students to check out.

Supplemental Instruction (SI).   Supplemental Instruction is a learning system that using collaborative group learning in discussion sessions that are attached to high risk courses. Students can voluntarily attend the discussions sessions throughout the week and students assist each other in learning the course material during the discussion sessions. To help students focus more during the discussion sessions, a student that has successfully passed the course leads the sessions and sometimes provides various materials to assist in the learning.

Supplemental Instruction Leader (SI Leader). The leader of the supplemental instruction sessions is a student that has successfully completed the course which they are leading and usually other subsequent courses. For example, a SI leader who has been successful in engineering calculus I, would usually also have been successful in engineering calculus II and possibly engineering calculus III.

Supplemental Instruction Supervisor (SI Supervisor). The supervisor for all SI leaders and SI supported courses. The SI supervisor usually is a faculty member of the department in which SI is being implemented, or it is a professional person that has been hired to run the supplemental instruction program.

Technical Calculus. A two-semester course at OSU designed for the following majors, among others: fire protection and safety, engineering technology, construction management, pre-med, and microbiology. The content is derivatives and integrals. In the first semester course, the students learn about analytic geometry, derivatives of algebraic functions, integrals of polynomials and generalized power functions, and applications of derivatives. In the second semester course, the students learn derivatives and integrals of transcendental functions and applications of derivatives and integrals, along with partial derivatives and functions in polar coordinates. A variety of freshman through seniors enroll in technical calculus preparing for class work in their major.

Technical Calculus Learning Supplement (TCLS). An online learning supplement for technical calculus that is located on the World Wide Web at www.math.okstate.edu/~millerd/TCLS.html. The website is designed to help students study for the course, review algebra skills, get help with their calculator, set up real world applications, work their homework by using worked examples for each section, and trigonometry review.

Organization of the Study

This study is presented in a five chapter organizational format. The first chapter provides a general overview, the foundation and statement of the problem, the purpose of the study, the assumptions and limitations, and the definitions of terms that will be used throughout the study. The second chapter will review relevant literature and will provide the framework for the study. Methodology will be discussed in the third chapter with information about the participants, the research design, the data collection procedures, instruments, and the procedures for analysis of the data will be described. The analysis of the data will be presented in chapter four, and the findings of the study as well as the conclusions, a call for future research, and the final comments will be given in the last chapter.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to review the research that is relevant to supplemental instruction, in particular, research on supplemental instruction for mathematics and supplemental instruction in which the researcher used a qualitative research design. This chapter is divided into the following topics: an explanation of SI and what constitutes an SI program, a history of supplemental instruction system, how supplemental instruction might be used with a mathematics course, qualitative research on supplemental instruction systems, and dissemination and variation of the supplemental instruction model. In addition, there is a section on collaborative and cooperative group learning, and the history of learning supplements and recent developments at Oklahoma State University.

Review of Supplemental Instruction Literature

What exactly is SI and what constitutes an SI program?

Supplemental Instruction, denoted SI, is a system that concentrated on offering academic assistance to the whole class through voluntary peer-led discussion sessions instead of the individual assistance that a student could get at his or her college or university academic learning centers. This varied dramatically from the assistance system that had been used up to that day, in which students would seek help in an academic center. These academic centers would usually tutor on a first come, first serve basis, or by appointment. Martin refers to the programs created by these academic help centers as “drop-in” or “crisis-oriented” programs. Students had to perceive that they needed academic help, or an instructor or teaching assistant would have to recommend that they seek academic help. One drawback was that usually six or more weeks had passed in the course before diagnosis of a problem had been identified for a particular student. The result of this diagnosis is that students struggling with a course often dug themselves into an academic hole academically that was irreversible.

Students who might have difficulty in a course are defined as “at risk students” or “high risk students” (Martin, 1993; Arendale, 1994, Winter; Hodges, 2001; Congos, 1993; Blanc, DeBuhr, Martin, 1983). Martin’s academic support model emphasizes “at risk courses” instead of “at risk students”(Arendale, 1994, Winter; SI staff, 1997; Blanc, Debuhr, Martin, 1983). The literature on SI (Arendale, 1994, Winter; Martin, 1993; Arendale, 1998; SI staff, 1997; Martin, Blanc, Arendale, 1996; Arendale, 1993; Hodges, 2001; Congos, 1993; Blanc, Debuhr, Martin, 1983), defines an “at risk course” as one where there are 30% or more grades of D and F in the class, along with withdraws from the course, but each institution has the freedom to designate any course an “at risk course” if it so desires (Arendale, 1994, Winter; SI staff, 1997); Arendale, 1993). Students will feel more comfortable getting help with an “at risk course”, because it puts the focus on the course instead of on individuals. This means that there is no stigma attached to students who attend SI (Arendale, 1998; SI staff, 1997; Arendale, 1994; Martin, Arendale, 1993; Martin, Blanc, Arendale, 1996; Hodges, 2001; Congos, 1993).

The key people in the SI system are the SI supervisor, the SI leader, the instructor of the course, and the participating students (Arendale, 1994, Winter; Arendale, 1998). The literature (Arendale, 1994, Winter) states that an SI supervisor is a trained professional who is part of the SI staff. After selecting the courses that will use SI, the SI supervisor selects the SI leaders and trains them for the upcoming semester. The SI supervisor also makes sure, beforehand, that the courses selected for SI have at least the support of the course instructor. During the semester, the SI supervisor will take time to monitor and evaluate SI for each course. The SI leader is usually a student who has been successful in the course or who was successful in a comparable course. To be successful, the student would have had to earn an A or B in the class, preferably an A, and have gone on to successfully complete at least the next course or two. Typically, the SI leader is an undergraduate student, but this is not always the case (Kenney, 1988). The SI leader is called a "model student" (Widmar 1994, Winter; Arendale, 1994, Winter; Arendale, 1998; SI staff, 1997; Blanc, DeBuhr, Martin, 1983), and in no way should be thought of as a replacement for the instructor. It is best for the SI leader to be assigned to a course that is taught by the same instructor whom the SI leader had when he/she was enrolled in the course. The SI leader will usually conduct three or more out of class, one hour sessions in which a proactive learning and study strategy is implemented; this, however, might depend on the subject area of the course (Widmar, 1994, Winter; Arendale, 1998; Arendale, 1994, Winter; Martin, 1993; Arendale, 1998; SI staff, 1997; Martin, Arendale, 1993; Martin, Blanc, Arendale, 1996; Hodges, 2001; Congos, 1993; Blanc, DeBuhr, Matin, 1983). For instance, it is recommended that mathematics supplemental instruction sessions be given more structure and time (Burmeister, 1994, Winter). It is most desirable for the SI leader to attend all lectures, take notes, and complete all major assignments in the course (Arendale, 1994, Winter; Arendale, 1998; SI staff, 1997; Congos, 1993; Blanc, DeBuhr, Martin, 1983), because the SI leader emulates being a model student by showing the students how to take good notes, how to process course information, how to recognize and study the important aspects of a teacher's lecture, and how to understand the material in the lecture. The SI sessions should use group learning techniques that are directed by the SI leader in order to get students to absorb the information internally and become independent learners (Marshall, 1994, Winter; Arendale, 1998; SI staff, 1997; Martin, Arendale, 1993).

Another key component is the integration of study skills in the SI sessions by the SI leader (Widmar, 1994, Winter; Arendale, 1998; Arendale, 1994, Winter; SI staff, 1997). The sessions should emphasize "how to learn" along with "what to learn" (Arendale, 1998; Martin, Blanc, Arendale, 1996; Congos, 1993). Arendale states "it is the planned integration that sets SI apart. We believe that by combining *what to learn* with *how to learn* it, students are able to develop both content competency and transferable academic skills that pay off in higher grades during future academic terms" (Arendale, 1994, Winter, p.15). One of the major differences between SI and collaborative learning or other academic learning techniques is that SI infuses study strategies along with course content (Arendale, 1994; Arendale, 1998).

The support of the instructor of the course can help SI work more effectively for a class. Faculty at an institution will make sure that the SI leaders are competent in the areas in which they will be used as SI leaders; and, as a whole the faculty is needed for SI success and support (Arendale, 1998). This support from the instructor comes in many different ways. For example, the instructor shows support by making announcements or references to the SI attached to their course during the delivery of course content. Many SI supervisors will not support an at-risk course if the instructor of the class is not supportive of SI being attached to the course. This is important since usually the SI leader will talk weekly or bimonthly with the instructor about concepts and topics that are not understood by the students, and in some cases, the information causes the instructor to change the way he/she is presenting material.

The participating students, it can be argued, are the most important key to any system. Supplemental instruction would probably not be around if any of the above key people were not involved. However, the reason supplemental instruction started was for the students, and that is the reason that it continues. For various reasons, students have difficulty with certain subjects. Supplemental instruction opens up an avenue for students to discuss these difficulties with other students and to discover what they understand and what they don't understand. Students in these supplemental instruction sessions, with the guidance of an SI leader, help one another. Supplemental instruction has been used in all types of courses at many different institutions. The next section discusses research studies in the subject of this study, mathematics.

History of Supplemental Instruction System

In the early 1960's, University of Kansas City (UKC) was a small private university that had a selective admission policy. The university, along with other undergraduate and graduate colleges, had professional schools of law, dentistry, pharmacy, and a conservatory of music. According to Widmar (1994, Winter), the

University of Missouri system grew to urban centers of the state and united with UKC to form the University of Missouri-Kansas City. This union resulted in dramatic changes in the academic structure of the old UKC. The renamed university changed the admission policy to admit lower-caliber students, and this caused the attrition rate of the university to soar from twenty to forty-five percent among entering students (Widmar, 1994, Winter). According to Widmar (1994, Winter), after several university committees had investigated the problem, Widmar, with the help of a seven thousand dollar grant, hired Deanna Martin to investigate the reason for the attrition in the professional schools. She investigated learning centers and concluded that most learning centers at the time operated on a system that did not serve the students thoroughly. The essence of the assistance that the learning centers used was from a drop-in system where (1) students had to perceive the need for help and (2) they had to have the incentive to get the help. Some of the findings of interviews that Martin conducted with directors of learning centers, found in Widmar's study (1994, Winter, p. 5) include:

1. The learning centers felt like they were not part of the mainstream values of the institution.
2. They were accorded little recognition and limited respect.
3. Learning Centers complained of being a "dumping ground" for the institution.
4. Diagnostic and standardized tests were insufficient to predict which students would need assistance.
5. They believed that their services were often "too little, too late."

6. They described the regularly scheduled remedial and developmental courses as “add-ons” to otherwise heavy class loads.
7. They could not demonstrate that students actually transferred the skills they learned to regular courses.
8. They reported that those students most in need of assistance avoided asking for help in a timely fashion, because they did not want to be stigmatized or labeled remedial.
9. The individual tutoring that they all offered was expensive, and many students failed to keep scheduled appointments.
10. Evaluation of the effectiveness of services was very difficult.
11. Financial support from the institution was tenuous.

Martin, using these findings and the committee consensus on the type of program that UMKC should implement, piloted the first supplemental instruction program in the school of dentistry in the early 1970’s. In 1973, Supplemental Instruction, denoted hereafter as SI, was launched as a full scale system in the professional schools of UMKC through an award from the Health Careers Opportunities program (Widmar, 1994, Winter). The growth continued with a small local grant from the Kansas City Association of Trusts and Foundations to the college of Arts and Science. The SI system received national attention when the United States Department of Education certified it as an Exemplary Education Program (Widmar, 1994, Winter). This certification allowed UMKC to obtain funds that would not be available otherwise, from the National Diffusion Network (Widmar, 1994, Winter). Arendale (1998) states that SI is used in more than 800 U.S. institutions "to provide an enriched learning environment for students to increase mastery." Furthermore, UMKC SI staff states in "Description of the Supplemental Instruction Program" (1997) that SI is used in Australia, Canada, Denmark, Egypt, Marshall Islands, Malaysia, New Zealand, Puerto Rico, South Africa, Sweden, United Kingdom, and the West Indies.

Using Supplemental Instruction with a Mathematics Course

Some students think that only certain types of people can understand mathematics and many students believe that they are unable to learn mathematics (Tobias, 1979; Moving Beyond Myths, 1991; Devlin, 2000). In "Supplemental Instruction Sessions in College Algebra and Calculus", the authors state that "success in mathematics requires daily practice and analysis, much like the repetitive work required to master a foreign language" (Burmeister, 1994, Winter, p. 53). College mathematics continue to trouble students because "far too many high school students, even among those who declare their attention to enroll in college, are still (being) allowed to graduate without the mathematics skills to complete minimum college mathematics requirements" (Ainsworth, 1994, p. 2). Students who come to college without an adequate background in math will likely withdraw from or quit performing when a math class becomes difficult (Ainsworth, 1994). Furthermore, even students who prepare themselves in high school by taking numerous math classes find themselves sometimes overwhelmed or inadequately prepared for college mathematics. Therefore, it is not surprising that the first six weeks of the academic term is the most critical for student withdrawal from the course and the institution (Noel, 1985), and in some institutions, the attrition rate for freshman math courses can be as high as sixty percent (Ainsworth, 1994). One way to combat the difficulties that students have with mathematics along with the high attrition rates, is in implementing supplemental instruction. Numerous studies have shown that supplemental instruction has been successful in mathematics (Kenney, 1988; Wright, 2002, Fall; Burmeister, 1994, Winter; Donelan, 1994; Allen, 1993; Kallison and Kenney, 1992).

The ultimate goal of supplement instruction is to move students from depending on instructors or outside help to being independent learners. "Students' inability to function as 'independent learners' put them at risk of continuing their high school patterns of low achievement or failure in mathematics courses" (Ainsworth, 1994). It is not an easy task to transition students from a place of dependency to a place of independency. In fact the literature calls for supplemental instruction sessions in mathematics to initially have a somewhat rigid structure (Ainsworth, 1994; Kenny, 1997), and as the semester goes on, the students should have more and more control of the sessions. Ainsworth calls for SI sessions to use protocols when solving problems (Ainsworth, 1994) and Kenney states that SI sessions can teach problem solving by using verbal protocols that list the steps of how to solve a problem without using any math notation (Kenney, 1997). These protocols are just step by step algorithms of how to solve specific problems. The SI leader will supply the protocols in the SI sessions for the first part of the semester, but will gradually move the responsibility in producing the protocols to the students as the semester goes on (Ainsworth, 1994). The reason for this would be that the students learn how to write protocols early on and they can experience success using protocols. This success often motivates them to produce their own, because they see that they really work. The benefits of protocols could extend beyond the course at hand and could also help them reap benefits in other courses (Ainsworth, 1994; Kenney, 1997). Examples should accompany the protocols (Kenney, 1997) so that students understand how to use the protocols.

The results of supplemental instruction in mathematics, and SI in general, are: 1) students who participate in SI earn higher mean course grades (a half of a letter grade or a letter grade higher) in the course than students who do not participate in SI, 2) students who participate in SI reenroll in college at a higher rate, and 3) the group of students who participated in SI had a lower level of D or F grades and course withdrawals. The researcher will now spend a little time discussing a few research studies on SI in a mathematics course.

SI has been attached mostly to various mathematics courses from developmental mathematics (Wright, 2002; Phelps and Ripperger-Suhler, 1992) to Calculus (Kenney, 1988). Kenney’s study at the University of Texas at Austin was one of the first studies of SI in mathematics. In the study, she performed the role of SI leader while she was a graduate student. Two large business calculus courses taught by the same instructor were each divided up into three discussion sections. Two of the discussion sessions were labeled the treatment group and SI was implemented in that treatment group. Another two discussion sessions were labeled the control group and SI was not implemented in this control group. Furthermore, Kenney did not implement SI in the discussion for the control group. The last two discussion sessions did not participate in the study. An observation instrument was designed by Kenney and implemented to “control for the threat of experimenter bias inherent in this model” (Kallison and Kenney, 1994, Winter). The groups were determined to be equivalent on a “set of important independent variables such as mathematics ability and achievement levels, high school class rank, gender, and college of enrollment" (Kallison and Kenney, 1994, Winter). The results of this study were: 1) students who participate in SI earn higher mean course grades (a half of a grade or a whole grade) in the course than students who do not participate in SI, 2) students who participate in SI reenroll in college at a higher rate, and 3) the group of students who participated in SI had a lower level of D or F grades and course withdrawals, however, "SI was not the only contributing factor." (Kallison and Kenney, 1994, Winter). In a follow-up study in which no SI was implemented, Kenney determined that the students who had participated in SI during the first semester showed no significant difference in their second semester business calculus grades and no difference in their course taking patterns than their non participating counterparts. So the study skills component of SI did not carry over to the next semester.

In two other studies, Kallison and Kenney used SI with business calculus students and calculus for engineering and natural science students. In the first study, two large business calculus classes, taught by different instructors, were each divided into three TA-led discussion sessions. SI was used in the three discussion sessions for one of the courses. The TA who led these discussion sessions received SI training while the TA who led the other three non-SI discussion sessions did not receive any SI training, but used a traditional content-only focus. Both classes took the same exams and final. Kallison and Kenney (1994, Winter) compared the groups on important quantitative and qualitative variables to ensure that there were significant differences between the two groups and concluded that the average course grade for the SI group (2.39) was significantly different than the non-SI group (1.96). These results, though, could be partly explained by the general teaching effectiveness of the two TA's (Kallison and Kenney, 1994, Winter). Furthermore, they investigated whether SI helped lower ability students more than higher ability students and concluded that it appeared that SI helped lower ability students disproportionately more than the higher ability students (Kallison and Kenney, 1994, Winter). The second study was set up similarly to the first study in that it divided two large lecture classes in engineering calculus each into three discussion sessions. Three discussion sessions for one class received SI techniques and the other three received content-only focus. The main difference between this study and the previous study is that the two classes were in different semesters and one TA led both sets of discussion sessions. The results showed that the average course grade for the SI group (2.00) was not significantly different than the non-SI group (1.91). This result was very different than those from the first study and could conceivably be different because the two lecture classes were in different semesters or because of TA differences in the first study. Other studies (McManus, 1992; Wright, 2002; Stephens, 1995; Douma, 1988), among others, have shown similar results to the above studies. Recall that these results were that: 1) students who participate in SI earn higher mean course grades in the course than students who do not participate in SI, 2) students who participate in SI reenroll in college at a higher rate, and 3) the group of students who participated in SI had a lower level of D or F grades and course withdrawals.

Qualitative Research on Supplemental Instruction Systems

Most of the research associated with supplemental instruction has been quantitative research, although some research has either employed a qualitative component or a more in-depth qualitative study. There were approximately a dozen papers, out of hundreds, that were found to employ some form of qualitative technique when a search was done on the website http://160.94.45.87/ris/risweb.isa. This website contains most papers written on supplemental instruction along with some other papers on similar learning assistant models. In this section, we will briefly look at some of the qualitative studies on supplemental instruction.

Lockie and Van Lanen (1994, Winter) used a qualitative questionnaire at the end of the semester in the SI supported Chemistry courses at Saint Xavier University. The questionnaire asked students "what aspects of SI were particularly helpful to you in enhancing your performance in chemistry?", "how can the SI program be improved?", and "should the SI program be continued?" The study was conducted from spring 1990 to Fall 1992 with 139 students participating in SI and it was reported that the participants of SI completed the questionnaire. Marshall in her research "Faculty development through Supplemental Instruction" had the Faculty reflect on their experiences with SI at the end of the semester. Others have used a quantitative and qualitative research design to study supplemental instruction. Jarvi (1998) studied the academic achievement of SI participants at an east coast university.

More of the research that has employed qualitative research designs is from SI studies conducted outside the United States. Ashwin (1993) studied how educational theory of SI matched the student experience at Kingston University. Carson and Plaskitt (Carson, 1994) studied supplemental instruction at University of Port Elizabeth in Republic of South Africa. This study investigated the perspectives of students, majoring in sociology and economics, regarding the effectiveness of SI in helping the students to acquire skills such as critical thinking, essay writing, and reading textbooks (Carson, 1994). The study concluded that students perceived four main reasons for the effectiveness of SI. The reasons stated were "improvement of learning ability, increased interest in the subject, a forum to meet new friends, and SI leader support" (Carson, 1994). The qualitative doctoral dissertation by Collins and Richardson simulated the study by Carson and Plaskitt at the University of Port Elizabeth the previous year. Collins and Richardson found two additional reasons for the effectiveness of SI; namely it was easy to participate in SI and made for an easier adjustment to university life. In addition, "they concluded that the focus of SI correlates with the needs of students and that SI has helped students to develop important skills." Kotze (1994) looked at the effectiveness of SI with entry level mathematics courses at University of the Orange Free State in the Republic of South Africa. He concluded that SI "supported increased academic achievement and mastery of math concepts" (Kotze, 1994). An undergraduate thesis written by Smit (1996) at the University of Port Elizabeth looked at attitudes toward skills, adjustment, and performance of a first year chemistry student when supplemental instruction was used in the course and Edelson (1996) qualitatively studied the experience of supplemental instruction program in relation to the first year at the university. Finally, Davis (1999) examined SI leaders at Indiana University Purdue University Indianapolis (IUPUI) on the benefits of participation in the SI program.

Qualitative methods allow one to more deeply investigate certain phenomenon. At the early stages of thinking about a research study on the TCLS, the researcher e-mailed David Arendale twice in the summer of 2003. Dr. Arendale on August 16, 2003 stated "I think that the qualitative approach is essential to really understand the impact of your program with the students. There is only so much to be learned from traditional quantitative methods. You not only want to find out “if it worked” which quantitative may do, but you want to know “why it did or did not” which is really only answered from a qualitative method.” The literature cited, generally used qualitative research techniques. Combine this with the literature on supplement instruction in mathematics and we begin to see that qualitative methods in mathematics courses that use supplemental instruction might yield different information on the implemented program and its effect on the students in the class. To further the basis of the program implemented in this study, the researcher now turns to examining variations of supplemental instruction and how the supplemental instruction model was disseminated in both the United States and overseas.

Dissemination and Variation of the Supplemental Instruction Model

In this section the researcher will first cover examples of the dissemination of the supplemental instruction model to institutions in the United States and also to institutions overseas. This will convey that anytime supplemental instruction has to be transferred from one location to another, there will be changes that have to take place in order for the model to work in its new location. Similarly, when faculty wants to implement the supplemental instruction model in their academic area, certain modifications might be warranted in order for the model to work in their area.

UMKC desired to translate the SI model to other locations, but had the challenge of disseminating it to institutions that were much different than UMKC. The first dissemination of the Supplemental Instruction model occurred in 1983 at Bethel College in North Newton, Kansas (Martin, 1994). Bethel College is a small religious college with an enrollment of 900 students who resided at the college and is not located in an urban area. In fact, the location of Bethel College is 30 miles north of Wichita, Kansas just north of Newton, Kansas. The population of the urban area of Kansas City is approximately 1.8 million people. Compare this to the population of Newton, Kansas, which in 2000, had a population of 17,190 people, and you see that choosing SI leaders became a more difficult task at Bethel College than what was experienced at UMKC. In addition, collecting data became more complex (Martin, 1994). The SI staff realized that SI was a "field-based programme" and "one which would be shaped by its users rather than ratified by its originators" (Martin, 1994). Dissemination continued in the United States at different locations, and in 1991 reached overseas to the United Kingdom. The SI staff realized with the attempts to disseminate SI overseas, it would have to vary the supplement program to a much greater extent than what it had to do with SI in the United States (Martin, 1994). In British Universities, cohorts of students follow a linear curriculum much like professional schools in the United States (Martin, 1994). Other differences in the supplemental instruction in the United Kingdom were: (1) SI generated much more interest by educators in the United Kingdom than it did with educators in the United States; (2) British Universities and Educators were more concerned with the outcomes of supplemental instruction and education as a whole than their United States counterparts; (3) British educators showed not nearly as much, if any, concern about SI leaders delivering "instruction which supplements the lecture" compared to educators in the United States. In the third point, the concern is that SI leaders should not try to become "mini professors" in the sense of trying to lecture over material that has already been covered in the class. They should only facilitate the learning of the students. All of this has caused the SI model in the United Kingdom to be different than the SI model in the United States; however, very similar results have been documented.

Variations to the original supplement instruction model have occurred at a local level also. In the last couple of decades, researchers have varied the supplemental instruction model in search of a solution to an academic problem at their institution. Sometimes the variation is considered a small variation or not even a variation at all, and at other times the variation would be considered a big variation. For example, a researcher might use a graduate student as an SI leader instead of an undergraduate student or have the sessions led by SI leaders instead of peers. Varying or experimenting with the format of supplemental instruction will have its advantages and disadvantages. Since the original model was successful, one might ask why vary the supplemental instruction model? There are several reasons, including limited resources, institutional restrictions, or course level. For example, it is not advisable to use supplemental instruction in remedial or developmental education courses (Arendale, 1994, Winter). Arendale in (1994, Winter) states, "The clearest evidence we have ever had of failure was in a college where SI was attached to remedial classes."

Knowing this, one might find the study "Developmental Mathematics Education and Supplemental Instruction: Pondering the Potential" quite surprising and one might think that "the authors of the study have defied conventional practice with their decision to implement SI in two developmental mathematics courses" (Wright, 2002, p. 30). There were good reasons why the authors decided to use supplemental instruction with 90 developmental math classes in the spring, summer, and fall of 2000 (Wright, 2002). (These good reasons included, 1) large class size in the developmental mathematics classes, 2) the developmental mathematics classes had extremely low pass rates, 3) large amount of material was being covered in class, and 4) adjunct faculty and teaching assistants were inexperienced with teaching under-prepared students.) Furthermore, the SI leader's role was modified because the authors didn't identify an SI leader until 4 weeks into the spring 2000 semester, and the SI leader only could attend one of the two lectures. Because of this, SI was not in place until after the first exam. The authors stated the results of the study in (Wright, 2002, p.30) as, "the student outcomes suggested that Supplemental Instruction may have made a positive difference in the performance and retention rates of developmental mathematics students when the instructor was actively involved in promoting the SI group and certain modifications were made to the traditional role of the SI leader in the classroom."

There were notable variations in the study done by Kenney (1988). She used herself, a graduate student, as the SI leader, although, up to that time, the leader was usually an undergraduate student. Furthermore, the course that she used in this study already had regular scheduled discussion sessions, and this was not the case in any previous study. In SI sessions, the SI leader is the facilitator and should focus the sessions so that they are student centered and student-run. Kenney (1997) states one exception to this rule of student-focused sessions is that "experienced teachers may be able to successfully employ careful explanations of problem solving processes if they provide at least some student centered time during the session" (Kenney, 1997, page 4). These variations discussed above are just a few of the many different variations that could occur or be useful in SI system. Kenney's examples give a basis for some of the variations in this study; furthermore, there are a few more variations in this study that are not mentioned predominately in the SI literature.

Collaborative and Cooperative Group Learning

In the lecture method and collaborative learning section of the background of the problem, we stated several author's definitions of collaborative learning and also discussed the benefits of collaborative learning. In the "using supplemental instruction in a mathematics course" section of the literature review, we discussed that supplemental instruction incorporates a collaborative learning structure and that Kenney has recommended more structure be given to supplemental instruction involving mathematics. In this section we will discuss the spectrum of group learning where collaborative learning is on one end and cooperative learning is on the other end. In addition, we will examine some recent research in both collaborative and cooperative learning and where the group learning in this study lies on the group learning spectrum.

"In the cooperative model the instructor maintains complete control of the class, even though the students work in groups to accomplish a goal for a course" (Panitz, p. 1). The instructor will have students work on answering questions or accomplishing course objectives, however, the instructor will maintain control throughout the time the students are working to accomplish the course goals. "In the collaborative model, groups would assume almost total responsibility for answering the question. The students determine if they have enough information to answer the question. If not they identify other sources, such as journals, books, videos, the internet, to name a few" (Panitz, p. 2). The group would decide how to divide the work among members; what resources need to be considered; how the resources should be used; what the final product of the group work will consist of, and how it will be reported; and how the group will be assessed. The researcher has just presented and explained the cooperative and collaborative models are the two ends of the spectra of group learning.

Slavin (1991) states few research studies on cooperative learning have been conducted at the college level. Since 1970, several studies at the college level have concentrated on comparing cooperative learning with traditional lecture method of instruction when dealing with mathematics courses. A few of these studies have integrated technology in the study. At Simmons College, Beers (1991) asserted that small group discussion resulted in increased student self-confidence when he used cooperative learning with microcomputer labs to teach calculus. A study conducted by Dubinsky and Schwingendorf (1991) claimed that the instructional method of using cooperative learning in a computer classroom was a more successful method of involving students in their own learning. Vodounon (1995) investigated the use of a computer software program called "Precalculus" in a cooperative learning environment involving undergraduates. Vodounon determined that the use of the computer software in a cooperative learning environment was not effective and that students' attitudes did not change toward mathematics at the end of the study.

While other research studies have not implemented technology, they have nevertheless compared cooperative learning to traditional lecture. Many of these research studies have examined academic achievement and attitude outcomes when dealing with group learning (Phillips, 1970; Price, 1971; Davidson, 1971; Chang, 1977; Shaughnessy, 1977; Norwood, 1995; Mears, 1995). The research study by Norwood (1995) compared the grades for students in a pre-calculus course in a two-year study. During the first year, students enrolled into pre-calculus after completing a prerequisite course in algebra that was taught by traditional lecture method. In the second year, students enrolled into pre-calculus after completing the same prerequisite course in algebra, but this time the prerequisite course was formatted to emphasize the use of cooperative learning when solving problems. The results of the study showed that 70% of the students were successful in completing pre-calculus as a result of completing the algebra course that emphasized cooperative learning. In contrast, only 46% of the students were successful in completing pre-calculus as a result of completing the traditional taught algebra course. This lead Norwood to conclude that cooperative learning was an effective method for improving mathematics achievement. In another study, Mears (1995) compared the effects of two instructional methods. The lecture method was used in seven sections of basic college algebra and a mixture of what the researcher calls "modified lecture" with cooperative learning techniques. Mears collected data on achievement and attitudes through pre and post-tests and "anecdotal" data was collected from interviews with students and faculty, student written evaluations, and observations in the classroom. The were no significant results on achievement and attitude between the two methods, but Mears found significance difference in the two methods that depended on the amount of time spent in class. There was no significant difference between the two groups, when the two groups were from a class that met on Monday-Wednesday-Friday class schedule. However, there was significant difference between the two groups when the two groups were from a class that met on Tuesday-Tuesdays for 80 minutes.

O'Brien (1993) examined the effects of cooperative learning versus lecture method on the attitudes, achievement, and attrition rates of college algebra students at Northwest Arkansas Community College. Two college algebra classes were taught by traditional lecture method and two classes were taught using cooperative learning methods. O'Brien used the scores on the final examination to measure achievement, attrition was measured by computing the percentage of students who completed the course, and students' initial and final attitudes were assessed using the Attitude Toward Mathematics Scale. The results of the study showed that there was no significant difference between the experimental group and control in the areas of achievement, attitudes, or attrition rates. O'Brien attributed these results with the weaknesses in the structure of the cooperative learning sessions. Valentino (1988) compared the effects of small group learning versus lecture discussion for two college algebra classes on the levels of academic achievement, math anxiety, and attitude towards mathematics at West Virginia University. Pre-test and post-tests were used to measure attitudes towards mathematics and math anxiety. Achievement was measured by administering a pre-test at the beginning of the course and using the course final as the achievement post-test. The results of the study showed that the small group discussion method produced significantly better results in achievement, reduced math anxiety in students, and increased positive attitudes that students had towards mathematics. Valentino concludes that instructors who are seeking ways to "promote successful completion of mathematics courses and to significantly lower the anxieties and negative attitudes of students in mathematics should consider implementing 'Cooperative Learning' techniques in the classroom" (p. 105). A few other studies have been conducted that have looked at academic achievement, attitude, problem solving ability, and critical thinking skills when using cooperative group structures (Olsen, 1973; Jones, 1992; Dees, 1991; Forbes, 1997). We will now look at two research studies that have used collaborative groups instead of cooperative groups.

One of the most known research studies involving mathematics and collaborative group learning is Treisman's study of black students at the University of California – Berkeley. Treisman (1985) developed mathematics workshops for the Professional Development Program (PDP) to help black students succeed in calculus. He found that entering freshman black students were not being as successful in calculus as other minority students, or in general, the other students in the class. Treisman stated that the first term of calculus "routinely proved a burial ground" for the career aspirations of minority students of a math based major (p. ii). He "questioned the efficacy of individualized tutoring, self-paced instruction, and short courses aimed at the development of study skills" (p. 2) After questioning "twenty black and twenty Chinese students about their study habits, methods of preparing for examinations, and the use they made of instructor's office hours" (p. 4), and examining the Chinese and black students more closely, he found that Chinese students usually work more in groups than black students. He began a pilot project in 1976 and the "mathematics workshops" emerged from this pilot project where workshop leaders worked with minority students and in particular, black students that were "interested in engineering, medicine, business administration, and other mathematics and science-intensive professions" (p. 62). For the workshops, Treisman developed problem sets that he called "worksheets" that consisted of difficult problems drawn from old exams and course textbook for the honors section of calculus. One of his main research findings were that "black Workshop students earn grades in Math 1A at a level comparable to class average, and about a full grade point higher than black non-Workshop students; and that black Workshop participants persist to graduation at rates comparable to the campus as a whole, while black non-Workshop students drop out at a substantially higher rate.

The workshop model has been used in other studies. A study by Hollis and Thomas used the collaborative workshop model in a Math Excel program at the Oregon State University. The Math Excel workshops were offered for a one-hour credit for college algebra and pre-calculus, and two hours of credit for differential and integral calculus. However, students did not have to enroll in the Math Excel workshops against their wishes because it was voluntary. Math Excel sessions were structured similar to the Workshops in Treisman's study where "students worked together in cooperative groups on problem sets" (Hollis, Thomas, p. 3). "Some problems were similar to homework problems and were intended to review and reinforce skills. However, many of the problems were chosen to be more challenging than typical homework or examination questions, and provided examples of application or extensions or highlighted common misconceptions held in relation to the course material" (p. 3). The results of the research showed that Math Excel participants earned over a half a grade point better on average than non-participants. Now we turn our attention to looking at the group learning structure that was used in this study.

In this study, participants voluntarily meet at least twice a week, two hours each time, to discuss problems from technical calculus in discussion sessions. These discussion sessions are modeled after the supplemental instruction sessions. Supplemental sessions use a collaborative group structure. However, Kenney (1988) suggested that more direction be given in supplemental instruction for a mathematics course. In this sense, the facilitator of the discussion sessions will help the students more during sessions by providing examples, worksheets, group exercises, and so forth. Students will still work in groups as well as individually in order to build understanding of the concepts. Therefore the discussion sessions for this study moves away from a collaborative group structure in supplement instruction to more of a whole/small cooperative group structure.

History of Learning Supplements and Recent Developments at Oklahoma State University

To contribute to student success in college algebra and to assist in retention efforts in biological sciences, Dr. Aichele, Dr. Noell, and Dr. Fox initiated an interdisciplinary project called College Algebra for the Biological Sciences or CABS. The project was funded by a grant form Howard Hughes Medical Institute during the academic year 1999-2000. Through this project, a hardcopy of the CABS learning supplement was developed and made available to students in biological sciences when they enrolled in college algebra at Oklahoma State University. In addition, students could find the CABS Learning Supplement on the internet. The CABS Learning Supplement consisted of four parts: How to Study Math, How to use the TI-83 Graphing Calculator, Applications from the Biological Sciences, and Learning Assessment Measures. The section on how to study mathematics was written with the college algebra audience in mind and discusses topics ranging from the transition from high school to college mathematics to how to prepare for an exam. The section on how to use the graphing calculator consisted of instructions on using a variety of calculator programs in college algebra. This section only included instructions and not the actual algebra programs; however, students could obtain the programs from their college algebra instructor. The section on applications was designed to show students sample problems from the biological sciences that tied into the topics that they were studying in college algebra. The applications allowed students to see the usefulness of college algebra for their specific majors. The final section was the Learning Assessment Measures (LAMS). The LAMS presented sample homework problems that were problems out of the textbook and, in a separate place, offered handwritten detailed solutions to those problems. The idea of this section is that after students have worked the sample problems and consulted the detailed solutions, they would be adequately prepared for the homework in the book and would be successful in completing the homework.

The Trigonometry for Biological Sciences (TABS) was modeled after the CABS project and was also funded by a Howard Hughes Medical Institute grant in 2000-2001. Before the beginning of the fall 2000 semester, the college of Arts and Sciences provided the names of more than 15 entering freshman enrolled in Trigonometry (MATH 1613) who were interested in the biological sciences. Of the students who were contacted to participate in the pilot study stage of the project, 10 agreed to participate. At the beginning of the 2000 fall semester, the principal investigators collected the participants' relevant information, which included past successful experiences in mathematics, goals for the course, and experiences with graphing calculators. Furthermore, during the semester, data was collected and monitored on achievement, attendance, participation at the math learning resource center (MLRC), e-mail contacts, and internet usage. The TABS Learning Supplement was made available to the participants on the internet or in hardcopy form. During the fall semester, participants were involved with weekly tutoring sessions with an undergraduate staff member. Average attendance for the weekly sessions, was four students each Tuesday night.

The project expanded during the spring 2001 semester; flyers were distributed to all students enrolled in MATH 1613 and the availability of the TABS Learning Supplement was announced. In addition, every MATH 1613 syllabus included a description of the TABS project and listed available materials for the course. The results for the project were very good. Students showed various responses to the end of the semester survey questions. In these surveys, the principal investigators listed the components of the TABS learning supplement and asked two questions about which component or components were the most helpful and least helpful in increasing the students understanding of the subject material and why. Most respondents felt the most helpful component was the LAMS help with understanding the course material, while most respondents felt the least helpful component was the section on graphing calculators, because they didn’t use it. In addition, several respondents commented that they did not use the videos and software at the MLRC.

The researcher began to teach courses in technical calculus during the fall 1999 term. During the fall 1999 term, the researcher taught two sections of technical calculus I. In addition, the researcher taught technical calculus II the next four semesters from spring 2000 through the fall 2001. During this time, Dr. Aichele and the researcher developed a learning supplement for technical calculus which we named the Technical Calculus I Learning Supplement or TCLS. The TCLS was modeled after the CABS and TABS learning supplement, along with two additional components. At various times while teaching technical calculus, Dr. Aichele and the researcher discussed that many students in technical calculus class had inadequate algebra skills. These students sometimes had trouble with concepts that they should have learned in high school algebra and improved in college algebra. For this reason, we saw the need for an algebra review component on the TCLS. Under the direction of Dr. Aichele, the researcher wrote the Quick Algebra Review (QAR) section on the TCLS. The QAR includes sections on exponents and radicals, algebraic fractions, completing the square, abstraction and notation, interpretation of the problems, exponential functions, logarithmic functions, and exponential and logarithmic equations. The idea of the QAR is that students will be more successful in passing technical calculus if they have an adequate understanding of college algebra.

In addition to the QAR section, Dr. Aichele and the researcher developed the Quick Trigonometry Review section (QTR), so that students could brush up on trigonometry before taking technical calculus II. The QTR includes sections on angles measured in degrees and special triangles, acute angles and the six trigonometric functions, reference angles and coterminal angles, six trigonometric functions, angles in radians and circular functions, graphing sine, cosine and tangent functions, trigonometric identities, trigonometric equations, and inverse trigonometric functions.

Both the QAR and QTR sections have problems for students to work in order to develop content understanding of each section. In addition, hand-written detailed solutions are provided separately from the problems so that students can work on the problems and compare their solutions to the detailed solutions.

CHAPTER III

METHODOLOGY

The purpose of this study is to describe students' perceptions and perspectives of the TCLS and discussion sessions, and students' experiences using the TCLS and discussions sessions. Furthermore, this study examines and compares the student's improvement in algebra skills over the course of the spring 2005 semester. Qualitative and quantitative data will be collected and analyzed on students' perceptions and perspectives of the TCLS, student's experience using the TCLS, and students' algebra skills at the beginning of the spring 2005 semester, during the course of the semester, and at the end of the spring 2005 semester.

This section begins by explaining why a qualitative research design was selected by the researcher, and will be followed by the research design, and descriptions of the participants including demographics on the class and participants, the instructional setting and sampling techniques, the physical setting of the discussion sessions, the three-step method used in the discussion sessions. This is followed by the instrument section, which provides an explanation for the instruments used. In addition, two pilot studies that were done to help mold the research study are presented along with an outline of the procedures involved in the research study, defining exactly how each part of the study will be conducted and how long each part will take to complete.

The research questions guiding this study, as stated earlier, were:

i. What are the experiences of technical calculus students with the Technical Calculus Learning Supplement (TCLS)?

   (a) What components of the TCLS do students use and why do they use those components?

   (b) What components of the TCLS do students not pay particular attention to and why do they not use them?

   (c) How do students use the components of the TCLS? (Are students using it the way we intended it to be used?)

ii. What are the students' perceptions of the TCLS?

   (a) What are the students' perceptions on how the TCLS helps them in the course?

   (b) How much do students attribute their success in the course to the TCLS?

   (c) What is the students' overall opinion of the TCLS?

iii. What are the experiences of technical calculus students with the group sessions?

   (a) What are the reasons for students to attend or do not attend the discussion sessions?

   (b) Are most of the students that attend the discussion sessions also students who attend the class regularly?

iv. What are the students' perceptions with respect to the group sessions?

   (a) To what extent do students contribute their success in the course with the discussion sessions?

(b) What are the students' perceptions of the three step method structure of the discussion sessions?

(c) What is the students' overall opinion of the discussion sessions?

v. How do the course grades and the pre and post-algebra assessment scores for those students who attend the discussion sessions and use the TCLS compare to students who do not attend the discussion sessions?

vi. When do the students use the TCLS?

vii. Are there parts of the TCLS that should be expanded and/or deleted?

viii. Should anything be added to the TCLS so that it better serves the students?

Using Qualitative Research Techniques

Although the majority of the research in supplemental instruction has used a quantitative research design, there have been some research studies that have used a qualitative research design. The reason for using a qualitative research design is that some research questions do not lend themselves to a quantitative research design. They simply cannot be answered using quantitative research techniques.

Research Design

According to Patton, phenomenology examines the meaning, structure, and essence of the lived experience of some phenomenon for a person or group of people (Patton, 2002). A phenomenological study will capture and describe how people "experience some phenomenon – how they perceive it, describe it, feel about it, judge it, remember it, make sense of it, and talk about it with others" (Patton, 2002, p. 104). The ‘lived experience’ for this study is the students’ use of the TCLS learning supplement and voluntary discussion sessions. Therefore this study uses phenomenology in order to examine the students’ experiences and perceptions with regard to the TCLS.

The Research Participants

The participants for this study are students from Technical Calculus (Math 2123) sections 1 and 2, spring 2005. The students participated in the study on a volunteer basis by signing an individual consent form, after the researcher has clearly articulated the study’s purpose and what the researcher expects from the participants. The participants attended some of the voluntary weekly discussion sessions for the course and were interviewed by the researcher near the end of the semester. In addition, near the end of the semester, the researcher asked non-participants if they would like help studying for their final exam. In return, the researcher asked the non-participant volunteers to agree to an interview with him prior to finals week. There were a total of 25 students who participated in some way to the study, which was comprised of 20 students who attended the discussion sessions throughout the spring 2005 semester, 3 students who attended some sessions, but stopped coming before the end of the semester, and 2 students who did not attend the discussion sessions, but agreed to an interview at the end of the spring 2005 semester in return for some help studying for the final exam. The researcher collected demographic information on each participant by using the student information system and the information was collected with the help of Dr. Bertholf.

First we will look at the demographics for the entire class. There were 87.6% males and 12.4% females who were enrolled in the course after the second week. The breakdown in the students' majors was: 31.0% FPST, 18.4% MET, 8.0% EETE, 25.3% CMT, and 17.3% other majors. The breakdown in class was: 21.8% freshman, 46.0% sophomore, 23.0% Junior, and 9.2% Senior. The average age of students in the class is 21.83 years. Seventy-six students were of traditional age (≤ 25 years old), with the other eleven students ranging from 26 years old to 32 years old. There were: Sixty-eight (78.16%) Caucasian students, three (3.45%) African-American students, ten (11.49%) American Indian students, one (1.15%) Asian student, four (4.60%) Hispanic American students, and one (1.15%) of another ethnicity. Looking at the mathematics course taken in college for all students enrolled after the early drop/add date, we found that: (73%) had taken college algebra, (67.4%) had taken trigonometry, (7.87%) had taken algebra and trigonometry, (16.9%) had taken intermediate algebra and/or beginning algebra, (22.5%) had taken either business calculus and/or calculus, and (17%) had taken other mathematics courses. Eighty students (89.9%) either took both college algebra and trigonometry courses, took just college algebra or just trigonometry, or took the combined algebra and trigonometry course. Also seventeen students (19.1%) took technical calculus at least one time prior to the spring 2005 semester. Finally, the stated prerequisite for the course is college algebra and trigonometry; however, if the student has a strong background in college algebra and/or trigonometry, then the student might be able to take technical calculus right out of high school. Thus, eighty students (89.9%) meet this prerequisite for the course.

There were 20 students who participated in the discussion sessions all semester. Three students attended some of the discussion sessions, but stopped attending the discussion sessions, for various reasons. One reason was that students had difficulty taking time off of work to come to the sessions. Another reason was students felt like their algebra knowledge was sufficient after attending several weeks of the sessions. The last reason was that students had family obligations which kept them from attending the last several months.

The demographics for the 20 participants will now be examined. Eighteen (90%) of the participants were male and two (10%) were female. The breakdown in the students' majors was: 35% FPST, 20% MET, 15% EETE, 25% CMT, and 5% other majors. The breakdown in students' class was: 20% freshman, 40% sophomore, 25% Junior, and 15% Senior. Eighteen (90%) were Caucasian, one (5%) was Hispanic American, and one (5%) was American Indian. The average age for the participants was 22.75 years old. Sixteen participants (80%) were of traditional age ($\leq$ 25 years old), with the other four participants ranging in age of 28 to 31 years old. Looking at the demographics of mathematics courses taken in college for all participants in the research study, we find that: (75%) took college algebra, (90%) took trigonometry, (5%) took algebra and trigonometry, (30%) took intermediate algebra and/or beginning algebra, (25%) took either business calculus and/or calculus, and (35%) took other mathematics courses. Every student (100%) either took both college algebra and trigonometry courses, took just college algebra or just trigonometry, or took the combined algebra and trigonometry course. Finally (10%) took technical calculus at least one time prior to the spring 2005 semester. Therefore, all participants meet the prerequisite for the course.

The 3 students that participated, but quit coming had the following demographics. All (100%) were male, all were Caucasian, they were 20, 22, and 28 years old, 2 were juniors and 1 was a senior, they were majoring in MET, FPST, and EETE. The breakdown of the mathematics demographics of these students are: 1) one student took college algebra and financial mathematics, 2) another student took college algebra, trigonometry and concepts of math, and 3) another student took both college and trigonometry, and technical calculus.

The two students who did not participate in the discussion sessions throughout the spring 2005 semester, but agreed to an interview at the end of the semester had the following demographics. One was a male and one is a female. One was majoring in MET and the other in BIMB. One participate was a junior and the other a sophomore and both were Caucasian. One had taken college algebra, trigonometry within the past few years, and withdrew from calculus I the previous semester, and the other had taken college algebra and trigonometry.

The Instructional Setting and Sampling Technique

The instructional setting was a technical course which is less theoretical than the traditional engineering calculus course. The course is procedural, emphasizing mathematical computations using derivatives and integrals applications to technical areas with little emphasis on the theory of derivatives and integrals.

The researcher has chosen to use a convenience sample for several reasons. First, students in this class cannot all be expected under reasonable conditions to need or want to be included in such a study. This study expects students to meet outside of class for at least two to four hours a week, and not all students have the luxury to be able to do this. Furthermore, some students master the material without using the TCLS or discussion sessions. This leaves a subset of the student population to volunteer for the study. Finally, the technical calculus supplement was designed for this course, and this study was modeled after studies of supplemental instruction which use a sample of students who voluntarily attend the sessions.

The Physical Setting for the Discussion Sessions

The discussion sessions were conducted in the computer classroom of the Mathematical Sciences Building at the same university where the research study was conducted. The computer classroom has 25 Pentium IV computers, all wired to the internet. In addition, the classroom is equipped with a projector that displays the computer screen of the instructor at the front of the classroom. The two hour discussion sessions were offered during the afternoon and evening. The specific times were chosen to fit student's schedules. The researcher chose the computer lab for the sessions because it allowed the researcher to use the video projector to show examples from the LAMS. Furthermore, students could use the computers to access the TCLS when they were working by themselves or in groups during the discussion sessions.

Interviewing

Stewart and Cash define interviewing as "a process of dyadic, relational communication, with a predetermined and serious purpose designed to interchange behavior, and involving the asking and answering of questions" (Stewart, Cash, Jr., 1994). Anderson, Herr, and Nihlen state that: "Interviews have been variously described as a conversation with another person, a verbal questionnaire, or a life story" (Anderson, Herr, Nihlen, 1994). Furthermore, Gay and Airaian define interviews as "essentially the oral, in person administration of a questionnaire to each member of a sample" (Gay, Airaian, 2000). Interviewing is one of the most common techniques of generating data in qualitative research. Seidman states "it is a powerful way to gain insight into educational issues through understanding the experience of the individuals whose lives constitute education." (Seidman, 1991, p.12). Mason (1996) comments that interviewing is a method that many researchers use to generate data at some point in their research, Seidman (1991) argues that interviewing is necessary and perhaps sufficient to generate data if the researcher wants to understand the meaning and experience that people make of education, and Denzin and Lincoln (2003) state that interviewing is a method that is most powerful and widely used by researchers in studying other human beings.

People are involved in interviews each and every day without even realizing it. Every time a person gives out information to someone or receives information from another person, an interview has taken place. Interviews in this research study will be considered as "information giving", as defined by (Stewart and Cash Jr., 1994, p. 5). That is, as "interviews where the primary function is to obtain facts, opinions, data, feelings, attitudes, beliefs, reactions, and feedback" (1994, p. 5). Therefore the researcher obtained facts, opinions, data, feelings, attitudes, beliefs, reactions, and feedback, when interviewing participants during this study.

Purpose of Interviewing

Interviewing helps an interviewer to understand the unobservable things, like thoughts, beliefs, feelings, and intentions of a person which are not visually observable. Patton states,

> the issue is not whether observational data are more desirable, valid, or meaningful than self-report data. The fact is that we cannot observe everything. We cannot observe feelings, thoughts, and intentions. We cannot observe behaviors that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things (2002, p. 340 - 341).

Cash and Stewart argue that the purpose of interviewing ranges from verify information to examining the perspectives, beliefs, feelings, attitudes and emotions toward some topic (1994, p. 9-10). Interviewing is gaining understanding of unique perspectives of a person and gaining meaning of how a person structures his world (Hatch, 2002, p. 23). By interviewing people, information can be collected and analyzed so that one might gain a deeper understanding of unobservable perspectives.

The Open-Ended Interview

Interviews can vary from closed ended questionnaires to interviews that are open-ended. A majority of qualitative studies employ open-ended interviews that range from a format that is structured to a format that is unstructured (Hatch, 2002, p. 23; Gay and Airasian, 2000, p. 220). In a structured open interview the questions are pre-determined and the interviewer does not deviate from the questions to probe other issues during the interview. Each interviewee is asked the same questions and their response is open to whatever they want to say. In an unstructured open interview the interviewer does not usually have a set of questions, but might or might not have a set of topics to be covered. The interviewer has the opportunity, when presented, to probe areas that are of interested to the interviewer as they come up. An interview that is somewhere between a structured open interview and an unstructured open interview is a semi-structured open interview. The researcher will use a semi-structured open interview for data collection in this research study.

Types of Questions and Time Frame Reference

Patton and Gay and Airasian state that there are six different types of interview questions. Interview questions essentially fall under one of the following types, which can be found in (Gay and Airasian, 2000, p.221) and (Patton, 2002, p. 348 – 351).

1. Experience and behavior questions.
2. Opinion and value questions.
3. Feeling questions.
4. Knowledge questions.
5. Sensory questions.
6. Background/demographic questions.

Table II below shows the types of questions asked on the long interview.

Table II

Types of Interview Questions for the Research Study

Types of Interview Questions	Open Ended Interview Questions																																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Behaviors/experiences												X	X	X	X	X		X		X	X	X			X		X			X			X	X	X				
Opinions/values											X			X	X	X	X	X		X	X		X	X		X			X		X	X	X	X	X		X	X	
Feelings/emotions																																							X
Knowledge																																							
Sensory																			X									X								X			
Background	X	X	X	X	X	X	X	X	X	X																													

Mixed Methods Design

Creswell states that mixing quantitative and qualitative methods probably originated in the late 50's when Campbell and Fiske multiple methods to study validity of psychological traits. Many other researchers started following suit, and mixing methods has come to be more widely accepted. Using one method to help develop or inform the other method is one strength of mixing methods (Creswell, 2003; Greene, Caracelli, & Graham, 1989).Greene and Caracelli (1997) state that one reason to mix methods in inquiry is "to generate deeper and broader insights, to develop important knowledge claims that respect a wider range of interests and perspectives" (p. 7). There are sequential, concurrent, and transformative strategies to use when a researcher is collecting, analyzing, and interpreting data. In this study, the researcher will use a concurrent strategy when collecting, analyzing, and interpreting data. Creswell defines a concurrent strategy as one "in which the researcher converges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem. In this design, the investigator collects both forms of data during the study and then integrates the information in the interpretation of the overall results" (p. 16).

Methods Used in the Discussion Sessions: The Three-Step Method

To assist students in learning the first semester of technical calculus, the researcher has introduced and used a method that is called the three-step method. This method capitalizes on the fact that many students are visual learners and learn through repetition. The three-step method enables students to transition from group interaction to a point where they have to produce the solution themselves. The three-step method is used in all of the TCLS discussion sessions and can be applied regardless of the topic. The three-step method begins by looking at a sample problem on the TCLS website over a topic in Technical Calculus (Math 2123). The researcher leads the group in reviewing the problem on the TCLS and interacts with the students to make sure that they understand the steps used to solve the problem. Next, a similar problem is presented on the blackboard. In this stage, the researcher asks the students to assist in solving the problem by telling him how to work through the given problem as a group. The amount of interaction depends on how much understanding they have on the topic at this stage and the difficulty of the topic. The final stage of the three-step method is to give the students another problem or problems and have the students work alone or in small groups. More independence comes during this stage, since students are solving the problem either by themselves or with a small group. Furthermore, during this stage, assistance is given to any student who is having difficulty with solving a given problem or having difficulty understanding the topic. After adequate time has passed for most students to have solved the problem, the final answer will be given. A complete solution would be given only if requested by a student. Through this type of collaboration, students will build confidence so that they can successfully work homework problems. In addition, students get exposure to the TCLS and see that they can use the TCLS to successfully complete their homework. During the sessions, students have said that they are not able to absorb material in lecture because they have to take notes. Numerous students have also expressed to the researcher that they use the TCLS when working on homework problems by themselves and when studying for the exams. Moreover, using the three-step method, the discussion sessions help students to better understand the course material.

Data Collection

Instruments used in the Study

Student Interviews over the TCLS. The semi-structured interview was designed in the spring 2004 with the help of Dr. Guzenhauser and Dr. Bertholf. The student interviews took place at the end of the spring 2005 semester. The researcher conducted the interviews individually with three different groups of students: 1) those who attended the discussion sessions throughout the semester, 2) those who attended the discussion sessions for a while, but stopped attending the discussion sessions, and 3) those who have never attended the discussion sessions but agreed to be interviewed. Each interview was tape recorded, after permission to audiotape had been given by the student that was being interviewed, and were transcribed in the summer of 2005. The transcription of each interview was given to the interviewed student to check the transcribed interview for accuracy. The responses to questions on the interviews were used as collected data to answer questions about the TCLS and discussion sessions.

TCLS Questionnaire. The TCLS questionnaire is an instrument that was designed by the researcher for the purpose of gaining insight on students' perspectives on the TCLS. The questionnaire was given to every student in attendance on a class day near the end of the spring 2005 semester. Thus the questionnaire collected student perspectives from both students that used the TCLS and students who did not use the TCLS. The TCLS questionnaire can be found in Appendix B and is similar to a supplemental instruction questionnaire developed by Congos (1999). The questionnaire uses a 5-point Likert-scale for some of the questions with the remaining questions being short answer or open ended.

Discussion Session Questionnaires. The discussion session questionnaires are instruments that were designed by the researcher for the purpose of gaining insight on students' perspectives and experiences with the discussion sessions. There were three types of discussion session questionnaires. The first type asked questions to students who had attended the discussion sessions throughout the semester. The second type asked questions to students who had attended the discussion sessions, but quit coming at some point during the semester. The third type asked questions to students who had never attended the discussion sessions. The discussion sessions questionnaires can be found in Appendix C.

Algebra Assessment Exam. The algebra assessment exam was designed by the researcher with the help of Dr. Bertholf. The purpose of the assessment is two-fold. First, the assessment measured the level of algebra skills each student had at the beginning of the spring semester in technical calculus. This beginning assessment score also established a baseline of the algebra skills that students have at the beginning of the semester in technical calculus. Second, the assessment measured the level of algebra skills with which students finished the course with. This assessment score also allowed the researcher to investigate the difference in assessment exam scores, from the beginning of the semester to the end of the semester, for each student. Furthermore, the difference between students who participated in the discussion sessions with students who do not attend the discussion sessions, were calculated. Finally, the assessment was used to encourage students to attend the discussion sessions. The researcher gave each student a summary sheet of the student's performance on the assessment and recommendations for success in the course. See appendix A for the algebra assessment exam and summary sheet.

The algebra assessment consisted of twenty algebra questions over the following seven topics: 1) basic algebra skills, 2) solving linear equations, 3) solving quadratic equations, 4) factoring algebraic expressions, 5) working with algebraic fractions, 6) exponents, and 7) evaluating algebraic expressions and functions. The breakdown on the assessment is shown in table III.

The summary sheet that was handed back at the beginning of the second week of class, showed the followed information: 1) total assessment score out of 20, 2) scores on each topic, and 3) recommendations for success in technical calculus with regards to algebra skills including references to a particular quick algebra review on the TCLS and another site www.purplemath.com, which reviewed other algebra skills not included on the quick algebra review.

Table III

Topics Covered on the Algebra Assessment

Topics on Algebra Assessment	# of questions on assessment for the given topic; which questions on the assessment for the given topic
T1 = Basic algebra skills	4; questions 3, 4, 5, and 6
T2 = Solving linear equations	3; questions 1, 7, and 12.
T3 = Solving quadratic equations	2; questions 8 and 17
T4 = Factoring algebraic expressions	2; questions 9 and 13
T5 = Working with algebraic fractions	4; questions 10, 11, 14, and 16
T6 = Exponents	3; questions 2, 19, and 20
T7 = Evaluating algebraic expressions	2; questions 15 and 18

TCLS Website Counter. Before the beginning of the spring 2005 semester, the researcher placed counters on each of the components of the TCLS. The researcher obtained a beta counter from www.gostats.com. The beta counter allows the researcher to keep counts on the number of hits for all of the pages of the TCLS website. In addition, the gostats website keeps track of hits that were referred by internet search engines. The counters help the researcher track how many students, during the course of the semester, went to different parts of the TCLS website. The results were used to determine what parts of the supplement were being used, how much students used the TCLS, and when those parts were being used. The researcher recorded daily counts for each component using Microsoft Excel.

Member Checking

As the fieldwork for a qualitative research study comes to a close, the researcher turns his attention from generating new data to verifying the collected data (Patton, 2002). The "most critical technique for establishing credibility" for the data is through member checking (Creswell, 1998). Member checking consists of the researcher asking the participants to check the accuracy and credibility of the various data that was collected during different stages of the research (Creswell, 1998). That is, the researcher shared his research findings with the participants, so that they might determine whether the data matched their experience in the study (Creswell, 2003). For this research study, after the long interviews were transcribed by the researcher, the participants were asked to check their transcribed interview to determine the accuracy and determine whether they need to delete, restate, or elaborate on any portion of the transcribed interviews. Furthermore, the researcher asked the participants to make any comments about the interview that they deemed important and the researcher asked the participants any follow-up questions during this time. The researcher asked the participants to member check their transcribed interview during the fall 2005 semester and return them by September 30, 2005. Half of the students either returned the interview by e-mail or returned a hard-copy of the interview.

Coding the Interviews and Discovering Themes

When coding the data, one turns the recognizable patterns in the data, into meaningful categories and themes (Patton, 2002). Patton states that

> "raw field notes and verbatim transcripts constitute the undigested complexity of reality. Simplifying and making sense out of the complexity constitutes the challenge of content analysis. **Developing some manageable classification or coding scheme is the first step of analysis.** Without classification there is chaos and confusion. Content analysis, then,

> involves identifying, coding, categorizing, classifying, and labeling the primary patterns for the data. This essentially means analyzing the core content of interviews and observations to determine what's significant"(Patton, 2002, p. 463)

Coding the data for a qualitative research study is a very time consuming and difficult job. The researcher coded using the following format: 1) The researcher added line numbers to each transcribed interview and when choosing an important phrase from each transcribed interview, the researcher used the label (A: B). The number A is a number between 1 and 22 which refers to the student being interviewed. The number B is the line number of that particular interview. 2) Once all transcribed interviews have been member checked and labeled, the researcher read through all the interviews and picked important phrases from each interview. The interviewer used the cut and paste feature of Microsoft Word to cut all important phrases with their corresponding labels from each transcribed interview, and pasted them into another document for each of the interviews. 3) The researcher then categorized the important phrases into emerging categories. 4) The researcher studied each category and came up with a title for each category. 5) The researcher examined each element of each category to determine if each element was in the correct category.

Triangulation of the Data

In land surveying, triangulation is used to locate an object with respect to two other objects. In data collection, triangulation can help strengthen the data by looking at phenomenon in different ways. Creswell states that triangulation helps “researchers make use of multiple and different sources, methods, investigators, and theories to provide corroborating evidence. Typically this process involves corroborating evidence from different sources to shed light on a theme or perspective” (1998, p. 202). Creswell also states that one should “triangulate different data sources of information by examining evidence from the sources and using it to build a coherent justification for themes” (Creswell, 2003, p. 196). Patton states that “triangulation is based on the premise that no single method ever adequately solves the problem of rival causal factors. Because each method reveals different aspects of empirical reality, multiple methods of observations must be employed” (2002, p. 247).

Triangulation of the data appears in this research study by collecting: 1) information about student’s perspectives on the TCLS and discussion sessions through questionnaires on the TCLS and discussion sessions, and the long interviews, and 2) information about the use of the TCLS and discussion sessions through the website counters, the questionnaires on the TCLS and discussion sessions, and the long interviews

Pilot Studies

Pilot Study #1

Pilot study #1 was conducted in the spring 2004 at the same large university where the study was conducted. This pilot study did not start until late March which was right before the second exam. Hence the pilot study was conducted for 6 weeks of the spring semester. The students who participated in the study were from the two sections of technical calculus I (Math 2123) on the main campus and were from the following majors on campus, but not limited to, fire protection and safety, construction management, mechanical and electrical engineering technology, pre-medical, and microbiology. Students volunteered to participate in the study by signing an individual consent form and attending the sessions. The students met with the researcher on Tuesday and Thursday nights from 7 to 9 P.M. in the mathematics learning resource center. The sessions were conducted using the three step method. Periodically when students were making algebra mistakes, for example, the researcher would show the section on the TCLS devoted to algebra review to all students in attendance. In addition, before the third exam the researcher showed the students in attendance the "how to study math" section of the TCLS so that they could get information on how to take exams. The researcher did not have time to do the same for exam 2 since the pilot study started the class right before the second exam. The night before the third exam there was a large increase in the number of students attending the discussion session. That night the session had 17 students who attended. In all 13 students attended two or more times and 8 students attended 4 or more times. The researcher interviewed all 8 students that had attended 4 or more times and 1 of the 5 who had attended 2 times. The interviews were conducted during the last two weeks of the course before the final exam and were conducted in a conference room in the university's education building. Each interview lasted between 20 and 30 minutes and the interviews were transcribed by the researcher during May 2004. The purpose of the pilot study was to get familiarity with working with students and introducing them to the TCLS. The TCLS had been advertised during regular class time the previous two semesters, but it is unknown how many students use the TCLS and how the TCLS helps them with the course. The researcher did program a counter on the website to count the number of visitors, however, the total count does not distinguish between new users or repeat users and did not differentiate which components were being used by the students. It is the hope of the researcher that students indeed visit the site many times because this tells the researcher that the website is useful. Furthermore, the pilot study allowed the researcher to improve the interview instrument that was used for the interviews and get practice conducting and transcribing the interviews.

Pilot Study #2

The second pilot study was conducted during the Fall 2004 semester at the same university that the research study was conducted. The students who participated in the study were from the two sections of technical calculus I (Math 2123) on the main campus and were from the following majors on campus, but not limited to, fire protection and safety, construction management, mechanical engineering technology and electrical engineering technology. Students volunteered to participate in the study by signing an individual consent form after the researcher articulated a clear description of the research study and what the researcher expected from each participant. The researcher met with the participants on Tuesday and Thursday nights from 8 P.M. to 10 P.M throughout the semester in a room that was equipped with 25 Pentium computers located in the building that housed the math department. The researcher used the three-step method during the sessions. There were 4 students initially attended the sessions with another 4 students attending after several exams had been given. The researcher did not conduct any formal interviews with any student, however, the researcher informally interviewed them frequently by talking to the participants about the TCLS and discussion sessions to get input from the participants. Through these discussions the researcher developed improvements in the research study. The researcher determined a counter was needed each component so that the researcher could better track the use of the website for each of the components. An algebra assessment was needed to determine the students' beginning and ending algebra skills. In addition to the stated improvements, the researcher would report the algebra assessment results to the students at the beginning of the semester to encourage students to use the TCLS to review their algebra. The researcher hoped that an increased emphasis on advertising the TLCS at the beginning of the next semester would result in more students using the TCLS and coming to the discussion sessions.

Confidentiality of participants

The researcher collected data from both participants and non-participants throughout the research process during the spring 2005. In order to ensure confidentiality of participants, pseudonyms were assigned to participants and will be used throughout the discussion of this study. All participants received a written assurance of privacy and confidentiality.

Procedure

This study was conducted in five phases. After the researcher obtained approval from the OSU Institution Review Board (IRB), the researcher implemented each of the following stages. The first phase was the administration of an algebra assessment to each student on the first day of class. This was carried out by the course instructors. The researcher graded each assessment, recorded the information on a summary sheet and a spreadsheet, supplied a copy of the spreadsheet to each instructor, and returned a summary sheet to each student which highlighted his or her algebra strengths and/or weaknesses, along with recommendations.

The second phase was ongoing the whole semester. It involved getting consent from students to be included as participants in the study. The researcher outlined the study to the students who voluntarily showed up at the discussion sessions. Since the discussion sessions are voluntary and the sessions are offered throughout the semester on different days of the week, students showed up at different times during the semester. Those students agreeing to participate in the research study signed an informed consent outlining the study.

In the third phase of the study, the researcher collected daily counts on the use of the TCLS by using beta counters for each component on the TCLS website. The researcher recorded counts on how many students visit each component each day and the total number of hits for each component. These counts were collected for each day throughout the spring 2005 semester.

During the fourth phase of the study, the researcher interviewed students over their perceptions and experiences when using the TCLS and discussion sessions. This phase of the study was administered near the end of the semester, approximately two weeks before finals. This phase of the study took approximately three weeks to finish.

The fifth phase of the study consisted of every student, present on a day near the end of the semester, worked the problems on the algebra assessment, completed a questionnaire over the TCLS, and completed the questionnaire over the discussion sessions. The post algebra assessment is the same as the pre algebra assessment and will be graded just as the pre-assessment was graded. The researcher will not return a summary sheet or provide the instructors with the results unless requested. The questionnaire that covers the TCLS asked each student questions over his or her use of the TCLS or non use on the TCLS. Furthermore, the questionnaire that covers the discussion sessions is made of three parts. One part contains questions about the sessions for students who attended the sessions throughout the semester, another asked questions for students who stopped coming to the sessions after some time, and a third part asked questions designed to determine why students never attended the discussion sessions. Students only completed the part that pertained to their status they had with the discussion sessions. This phase lasted one day.

CHAPTER IV

FINDINGS

This research study combined qualitative and quantitative data gathered from participants who were enrolled in technical calculus I during the spring 2005 semester in order to describe students' perceptions and perspectives of the TCLS and discussion sessions, student's experiences with the TCLS and discussion sessions, and to examine the student's algebra skills. The results of this research will help shed light on how and why students used the TCLS. In addition, the results of this research will describe the type of help students are receiving from the TCLS. Furthermore, the results will describe some of the reasons students were motivated, and why they were motivated to use the TCLS. Finally, the research will help the researcher to design better learning supplements and instructional tools that will help students be more successful in various math classes.

In this chapter research data will be presented that was gleaned from interviews, questionnaires, website counts from each component on the TCLS, and pre/post algebra assessment. The research questions guiding this study, as stated earlier, were:

i. What are the experiences of technical calculus students with the Technical Calculus Learning Supplement (TCLS)?
   (a) What components of the TCLS do students use and why do they use those components?

(b) What components of the TCLS do students not pay particular attention to and why do they not use them?

(c) How do students use the components of the TCLS?

ii. What are the students' perceptions of the TCLS?

(a) What are the students' perceptions on how the TCLS helps them in the course?

(b) How much do students attribute their success in the course to the TCLS?

(c) What is the students' overall opinion of the TCLS?

iii. What are the experiences of technical calculus students with the group sessions?

(a) What are the reasons that students attend or do not attend the discussion sessions?

(b) Are most of the students that attend the discussion sessions also students who attend the class regularly?

iv. What are the students' perceptions with respect to the group sessions?

(a) To what extent do students contribute their success in the course with the discussion sessions?

(b) What are the students' perceptions of the three step method structure of the discussion sessions?

(c) What is the students' overall opinion of the discussion sessions?

v. How do the course grades and the pre and post-algebra assessment scores for those students who attend the discussion sessions and use the TCLS compare to students who do not attend the discussion sessions?

vi. When do the students use the TCLS?

vii. Are there parts of the TCLS that should be expanded and/or deleted?

viii. Should anything be added to the TCLS so that it better serves the students?

In this chapter, three major sections will be presented. First, qualitative and quantitative data will be examined to determine the experiences students had with the TCLS and discussion sessions. Second, qualitative and quantitative data will be examined to determine students' perceptions of the TCLS and the discussion sessions. Third, qualitative and quantitative data will be examined to determine whether there were any differences in algebra skills between students who attended the discussion sessions and used the learning supplement with students who did not attend the discussion sessions at all during the semester. In the final section, qualitative data will be examined to determine the perceived benefits students received from the TCLS and discussions sessions. This chapter will be concluded with a summary of the data.

A Brief Look at a Few of the Participants in the Research Study

In this section the researcher will give a brief sketch of 4 participants in the study, 1 participant that stopped coming to the discussion sessions, and 1 non-participant who interviewed with the researcher at the end of the semester. The researcher chose these particular students to give an idea of the wide range of participants in: major, class, age, math background, and performances in previous math classes. Each of the brief sketches will include the student's major, class, their highest ACT composite score, their highest ACT mathematics score, previous college math classes taken with grades, and some selected comments from the students about their high school and college math background. In addition, the researcher will state if the student is right out of high school, has been out of high school for several years, or has been out of school for many years. These were included to give the reader examples of the type of students enrolled in the course.

Alex is a junior majoring in construction management technology. It has been five or six years since Alex was in high school and so he did not take the ACT to gain admittance to the university. He did have trouble with college algebra and trigonometry and stated that he was frustrated in his previous college math courses. His mentality was to throw his hands up and quit when he did not understand the math, and this resulted in a lot of struggles in college algebra and trigonometry. In the spring of 2000 he failed college algebra and dropped down and took general mathematics at a state college and basic mathematics at a branch campus of the present university he now attends. Two more attempts at passing college algebra at the smaller state college resulted with him withdrawing the first time in fall 2003 and failing again the second time in spring 2004. Finally he successfully passed college algebra in the summer of 2004 with a grade of an A. The next semester he enrolled in trigonometry and completed the course with a grade of an F. This semester Alex enrolled in both trigonometry and technical calculus.

Dalton is a sophomore majoring in electrical engineering technology. Dalton started college right out of high school and received an ACT math score of 21 and an ACT composite score of 20. In addition, Dalton preformed well in college algebra and trigonometry, earning a B in college algebra in the fall 2003 and an A in trigonometry in the fall 2004. Dalton has expressed that he has matured a lot since first coming to school and that he does a lot more problems than what he did when he first came to school. He stated the hardest thing to get used to in college algebra was that he was surprised by the number of students in the class and had a hard time finding help.

Henry is a freshman majoring in fire protection and safety. Henry decided to go to school here because this university has one of the best programs in fire protection and safety. He took the SAT instead of the ACT and scored a 510 on the math portion, with an overall score of a 980. Before Henry arrived on campus, he successfully completed intermediate algebra at a college in a state near where he resided with his parents. He successfully passed college algebra and trigonometry when he arrived on campus, earning a C in both during the spring and fall of 2004. He admits that he hated math in high school and college other than the second semester of his senior year in high school, when he frequently worked on his math skills with his pre-calculus teacher. Henry said that he liked math that semester because his teacher helped him understand math and got him to think about math more than during any other time in his high school career.

Neal is a sophomore majoring in mechanical engineering technology. Neal is an adult student who is married and has two children. He works at a company in a nearby town and lives about twenty miles away from the school. He did not have to take the ACT for admittance to the university. Neal originally started working on a degree in mechanical engineering and earned an S in intermediate algebra in the fall of 2002. He followed intermediate algebra by earning a B in college algebra in the fall of 2003 and a C in trigonometry in the spring of 2004. After earning an F in engineering calculus in the fall of 2004, Neal changed his major to mechanical engineering technology, with the encouragement of his boss, and enrolled in technical calculus.

William is a junior majoring in electrical engineering technology. William attended the discussion sessions for about a month and then stopped coming. William returned to school after dropping out of college and serving in the navy for six years. William said that he was more concerned with partying than concentrating on college when he attending college right out of high school. When in college the first time, he earned an F in financial math in the fall of 1997. He did earn an A in college algebra in the summer of 1998 at another school in Oklahoma. During his time with the navy, William said that he matured a lot, and is now fully concentrating on doing as well as he can in electrical engineering technology. William enrolled in technical calculus without taking trigonometry.

Quentin, a non-participant, is a junior majoring in mechanical engineering technology. Quentin scored a 23 on both his ACT math and ACT composite tests. In addition, Quentin earned an A in college algebra at a college in the southern part of Oklahoma and a B in trigonometry at the same university where the research study was conducted. Quentin, like Neal, tried to take engineering calculus and withdrew from calculus during the fall of 2004.

A Look at Previous Academic Performance

In this section, we will quickly look at the past academic performance of students in technical calculus by looking at their past G.P.A. at the same university where the research was conducted. The G.P.A of each student will give the reader an idea of the previous collegiate academic performance of the students who used the TCLS and discussion sessions and those who did not. The G.P.A that was used for this data was the institution G.P.A for each student unless the student was in his or her first semester as a transfer student or was a freshman at the university. The G.P.A. for these two types of students is denoted in the table with a * by the G.P.A. It should be noted that the G.P.A. might be or might not be an accurate predicator of academic performance in technical calculus. Transfer students' G.P.A will be their G.P.A at the university from which they are transferring from and might not accurately display their future academic performance in technical calculus at the university where the research study was conducted. In fact, all students' future academic performance in technical calculus might not be captured by their current institutional G.P.A., but at least this gives the reader an idea of where students stand going into technical calculus with respect to past academic performance and each other. The reader can see that the past academic performance of participants in this study varies greatly, as does the past performance of non-participants. By looking at table IV, one can see that participants in the study were not all students with similar past academic performance.

A Closer Look at the Mathematics Background in Technical Calculus

In the background of the problem we looked at the D-F-W rate for technical calculus for the past fifteen semesters, and in chapter III we looked briefly at the mathematics demographics of the entire spring 2005 technical calculus class. In this section we will look more closely at the mathematics background of technical calculus students and state some of the participants' perspectives on why technical calculus might be hard for students to comprehend. The perspectives are from participants in the study and hence might align or might not align with the perspectives of the non-participants. In order to ensure confidentiality of participants, pseudonyms were assigned to participants.

There were 32 students who completed and returned the discussion session questionnaires during the spring 2005 semester. Out of these 32 students, 13 attended the sessions throughout the semester, 4 students attended the sessions but stopped attending sometime during the semester, and 15 students never attended the sessions. All 32 students were asked about courses taken in high school. The responses included: 22 students had taken pre-algebra, 29 students had taken algebra I, 30 students had taken geometry, 26 students had taken algebra II, 17 students had taken trigonometry, 12 students had taken pre-calculus, 6 students had taken calculus, no students had taken either business mathematics or statistics, and 4 students had taken other mathematics classes that included algebra II (2 students), math modeling (1 student), and analysis (1 student). During some of the interviews with the participants, they commented on their background in high school mathematics courses. Rachel stated, "high school math was bad for me, I was not a very dedicated high school student. I never did any homework, ever. I would just go in and take my tests. I would average C's and B's, but I didn't retain it" (18: 476 – 478). (Recall that (A:B) represents the reference from the students transcribed interview where B stands for the page # in student A's transcribed interview where the quote appears). Examining what courses Rachel had taken in college before she enrolled in technical calculus, we find that she took beginning algebra, intermediate algebra at a community college, and withdrew from college algebra before earning a B in the summer of 2004. Although Rachel commented about how bad high school math was, Henry found high school mathematics enjoyable his senior year when he stated "my senior year I had a good experience with math, I think it was pre-calculus and college algebra. I had a good experience second semester, worked with a teacher a lot and it was

Table IV

Past Academic Success for Participants and Non-participants

Participant or Non-participant	Technical Calculus Grade	Past G.P.A		Participant or Non-participant	Technical Caclulus Grade	Past G.P.A
Elliot	B	4.000		Student 32	C	2.615
Student 1	A	3.769		Student 33	W	2.615
Student 2	B	3.750		Student 34	W	2.607
Student 3	A	3.591		Oliver	C	2.600
Student 4	W	3.545		Student 35	C	2.595
Stopped 1	C	3.538		Student 36	C	2.556
Valerie	A	3.529		Student 37	W	2.548
Jeremy	B	3.500		Student 38	B	2.439
Student 5	B	3.478		Student 39	B	2.435
Student 6	C	3.400		Student 40	W	2.429
Student 7	W	3.371		Student 41	D	2.421
Student 8	B	3.367		Neal	D	2.364
Student 9	A	3.302		Stephen	B	2.333
Student 10	A	3.250		Student 42	W	2.316
Student 11	A	3.250		Patrick	A	2.266
Student 12	W	3.226		Student 43	B	2.227
Kendrick	B	3.222		Student 44	F	2..227
Student 13	B	3.200		Student 45	B	2.222
Student 14	F	3.122		Student 46	C	2.220
Student 15	B	3.075		Student 47	W	2.171
Student 16	B	3.071		Alex	B	2.143
Brett	B	3.067		William	A	2.140*
Henry	C	3.067		Quentin	D	2.136
Dalton	B	3.044		Student 48	F	2.082
Isaac	C	3.038		Student 49	B	2.065
Timothy	B	3.000		Student 50	D	2.048
Student 17	W	3.000		Student 51	W	2.031
Student 18	A	2.933		Student 52	W	2.000
Student 19	A	2.920		Student 53	F	1.983
Student 20	B	2.917		Fred	C	1.949
Gregory	C	2.917		Student 54	D	1.893
Student 21	A	2.867		Student 55	F	1.870
Student 22	F	2.857		Student 56	C	1.789
Student 23	B	2.841		Casey	D	1.750
Student 24	B	2.825		Student 57	F	1.750
Student 25	A	2.791		Rachel	C	1.742
Student 26	F	2.711		Student 58	F	1.667
Student 27	B	2.700		Student 59	C	1.462
Student 28	B	2.694*		Student 60	W	1.115
Stopped 2	C	2.667		Student 61	F	1.077
Student 29	W	2.667		Student 62	F	0.813
Student 30	C	2.646		Mary	B	n/a
Student 31	W	2.643				
Lincoln	C	2.632				

the only time that I enjoyed math" (8: 351 – 353). Henry stated that he did not enjoy math before his senior year other than when he was in elementary school. However, this teacher that Henry worked with made it enjoyable for Henry to learn math once again. Alex and Elliot commented about how high school math was easy when they stated "high school math I did very well. I got A's" (1: 409), and "high school math was kind of mixed because my algebra teacher was not that great. I got an A in that class just because she was really not teaching up to her level. I was actually normal in math and there was an advanced group in high school and for some reason they never put me into [the] advanced [group] so that when I was just in the regular scheduled [class], it came real easy [for me]. I did the homework that I had to in math and played calculator games most of the times during class and still understood it better than anybody else in the class. It was real easy for me" (5: 112 – 118). Brett commented upon how high school math and lower level mathematics was about following a process when he asserted that "it seems like the lower level math that even in high school, you could follow step by step for every problem and it would be the same" (2: 334 – 336). We see that participants varied in how they felt about past math courses and how hard these courses were for them.

Looking a little deeper into previous mathematics courses in college we find that 23 out of 87 students, who initially enrolled in technical calculus, had taken courses in mathematics that were at a lower level than college algebra. Furthermore, the breakdown in grades in college algebra were as follows: 20 students received A's, 23 received B's, 15 received C's, 12 received D's, 3 received F's, 7 withdrew, 13 did not take college algebra, 5 took Math 1715, 1 received a P, and 1 had passed the CLEP exam on college algebra. This grade distribution included students who took college algebra multiple times with 9 students having to take college algebra between 2 and 5 times before they successfully completed the course. Of the 24 students who either interviewed with the researcher (19 participants and 2 non-participants) or stopped attending the discussions (3 students), 6 received A's, 4 received B's, 3 received C's, 2 received D's, 2 received F's, 2 withdrew from the course, 4 did not take college algebra, and 1 took Math 1715. The 2 participants that withdrew had to retake college algebra. One of these participants completed college algebra after taking it twice and the other participant completed college algebra after taking it four times. During some of the interviews with the participants, the participants commented on their background in college mathematics courses. Brett talked about how difficult it was trying to work and understand the homework when he stated "all I would have is the book and the notes that I took in class, so it was just so frustrating at some points during the course because I was just trying to understand [the] stuff" (2: 321 – 323). Casey talked about how trigonometry was more difficult than he thought it would be when he said "I took trigonometry here. It was my first semester up here and it was a little harder than I thought it would be" (3: 180 – 182). Although Brett and Casey had troubles with trigonometry, Elliot found trigonometry easy when he stated "in trigonometry the teacher did not require us to do any of the homework at all. She said these are some problems that you can look at for the test, but the homework did not count for anything. I did maybe two homework problems all semester and opened the book on occasion. Just studied my notes for the test [and] looked over them and still got a 96 or 97 on tests. It came just that easy for me" (5: 103 – 107). Some students commented on courses other than trigonometry. Other students talked about their experiences with pre-calculus and business calculus courses. Stephen stated "one of the calculus classes was in high school, but it wasn't very advanced. It was basically was like advanced algebra" (19: 19 – 20) and "I also took a business calculus course, I guess applied calculus, and I don't know if it was the professor or the material, but I didn't pick it up at all. I was in the class for maybe two weeks and after that I decided that I had enough" (19: 20 – 23). Fred went a little further, saying that his problems with business calculus was procrastination with the homework and commented that "I would wait until the last minute and then I would rush everything and really wouldn't understand it [at] all. But I ended up passing the class, but not with a pretty impressive grade" (6: 104 – 106). Experience with college math varied greatly for participants.

We have seen that on average the D-F-W rate for technical calculus the past 15 semesters is 42.95%. The enrollment for technical calculus has ranged from a low enrollment of 61 in the spring 1998 semester to 103 students in the fall 1999 semester. The average enrollment the past 15 semesters has been 85.67 students, with the enrollment the past 8 semesters between 80 and 95 students. This equates on average to around 36 to 37 students who will drop the course, fail the class, or earn a grade of a D in the course in any particular semester. During the spring 2005 semester, 38.9% of the students who were enrolled in the course after the first week of class either withdrew at a later date, failed the course, or earned a final grade of a D. The breakdown of the D-F-W rate is that 39 students, out of 88, fell into the D-F-W category with 7 students earning a D, 11 students failing the course, and 16 students withdrawing. There were a total of 22 students who participated in the discussion sessions. Three students stopped attending, and 1 student stopped attending after the second exam, but started attending again before the final. Out of the 22 students only 2 students fell into the D-F-W category with both students earning a D in the course. Thus no participants dropped the course or earned a failing grade in the course. The researcher is not saying that the participants did not struggle with the course, however unlike some of the non - participants, the participants did not get to the point that they considered dropping the course or performed at a level that would earn them a failing grade. Although the participants did not constitute a big portion of the D-F-W rate, they did shed some light on some of the difficulties students tend to have with technical calculus. Some of these difficulties could possibly be why other students have difficulty in technical calculus and might be why they receive a grade of D or F, or withdraw.

One initial difficulty was that participants were leery about technical calculus. They either thought that math was their weakest subject, they had a fear of calculus, or they dreaded taking calculus. This can be seen from the following quotes from Alex, Gregory, Henry, Isaac, Mary, and Oliver. Alex commented that "I thought that it [the class] was going to be something I was going to have to work at, to get through …. I wasn't for sure how I was going to get through it" (1: 8 -10). Gregory states "I hadn't had a whole lot of math and math definitely has been my weakest subject. I was dreading taking it" (7: 10 – 11), and "… coming into it [class], I was definitely dreading taking another math course" (7: 8 – 9). Henry comments about his lack of ability in math and his initial thoughts about how difficult the class was going to be when he states, "you know I probably just had to accept it, because I am not naturally good at it like a lot of people" (8: 388 – 390). "[I] thought it [class] was going to be a lot worse than what it actually was" (8: 10 – 11). Isaac adds, "I have always had trouble with calculus" (9: 100). (Isaac took pre-calculus in high school and withdrew from engineering calculus during a previous semester.) Mary remarks about the stories other students have told her that have shaped how she thinks about calculus. “I was really nervous and I have always heard horror stories about how hard calculus was and even though technical calculus is a slower version of that, still how difficult it was. So it made [me] really nervous; I was pretty convinced” (13: 275 – 278). Finally Oliver comments, “I think that it [class] has been challenging. [For] a lot of people, math is not their subject [and] this is the most challenging subject for me” (15: 151 - 152). For some of the students calculus seems like a daunting task for them to overcome. They have various thoughts going into calculus and they have to overcome those thoughts as they learn that they can understand calculus.

Another difficulty revealed through interviews was that calculus is tougher than other mathematics classes. Probably the best student in the class had a very good view about college algebra and why calculus is tough for some students. William’s view is that

> people who are naturally good at math and who have had a lot of math in high school, they take college algebra and it is a rehash of everything they did in high school, because Oklahoma high schools require algebra II for graduation. So they may get into a couple of new concepts, but for the most part it is just going over all the stuff they done before, whereas once they get into calculus the majority of the class will never have seen the material before. That right there means that they got to step up their commitment to it [technical calculus]. They aren’t recalling anything, they are learning new information (22:78 – 85).

William goes on further and states that “for one thing it [technical calculus] is remembering some relative complex formulas and some relative complex ideas” (22: 72

– 73). In addition, Alex, Henry, Mary, and Neal, explain that technical calculus is a tougher course and the hardest math classes they have taken when they make the following statements. Alex states “this [technical calculus] is one of the hardest classes that I have taken thus far in math” (1: 273). Henry comments that he thought calculus was going to be a challenge, “especially what I have heard coming in [to this class], it is a rough class” (8: 34). Mary remarks about adjusting to calculus when she says, “this is a hard adjustment for me because calculus is tougher” (13: 215). Neal, who struggled at times in the courses, states, “well I have had some stumbling blocks and it has been somewhat difficult for me and I don’t quite get calculus that well” (14: 8 – 9). For a variety of reasons students felt that calculus was harder than other classes that they have taken in college.

Some other difficulties that were revealed during interviews were that the students had a hard time working the homework or a hard time studying for the exams or working through the exams, Calculus problems are not as easy as step by step problems in algebra, students had a long elapsed time between a previous math course and technical calculus, students had a hard time comprehending calculus, and students had trouble understanding calculus by themselves. Isaac states, “trying to go over my notes and everything and going to do the homework problems, I found myself actually getting jammed on a lot of them” (9:23 – 24). Mary comments, “I had the time to do it [homework] and I choose not to because once I got to a certain point I just [would] get angry and shut down and I can’t go any further” (13: 39 – 40). Dalton remarks that “it was real hard for me to learn and know what was going to be on the test … that is why I have struggled really a whole lot. Because I tried to go over the practice problems that he set out for us but it did not work”

(4: 31 – 35). Rachel states that she would feel confident going into the test, "but for the test it seems like I get to the test and it doesn't seem like anything that we have done even though we have. Somewhere along the line I just forget what I have done. I don't know if it is a test anxiety" (18: 131 – 135). Brett comments about his difficulty with calculus because you had to think about how to work problems. He states that, "when you get up to the higher levels like calculus I, every problem can have different circumstances, different situations, and you are studying to see, I wouldn't say every situation, because that would be impossible, but at least the general idea of how to start off a problem with a particular circumstance. Now you have to actually think about doing the math" (2: 336 – 340). Elliot remarks that in "high school I could just grasp it [math] in my head, I could actually see it, but calculus … I don't know if it was just the way calculus is or I wasn't getting it … I couldn't grasp it, I couldn't figure out logically how to do it" (5: 126 – 128). Alex says that his trouble with calculus is remembering all the mathematics he had learned five to six years ago. "I have been out five or six years until I started back … that is just a long time without any math, so you forget almost every rule that was every taught to you in high school" (1: 410 – 412). Rachel comments that she has trouble just understanding calculus. "For some reason my brain does not click when it comes to calculus. I just look at it and literally see… it is almost like looking at greek" (18: 98 – 100). Finally, Patrick states, "as the class went on it seemed like after that [trying to get help from MLRC and from the website] you were on your own, and for some reason me being on my own wasn't working" (16: 24 – 25). Again many of the difficulties that students have with calculus vary from student to student, but many of the reasons are connected back to students not having a firm understanding of the rules of calculus.

We find in the above quotations from participants, why they had trouble with technical calculus and how these difficulties might overlap with the trouble that non-participants had with technical calculus. At least it offers the reader an idea of some of the reasons why students have difficulty with technical calculus. We will now turn to examining the experiences participants have with the TCLS and discussion sessions.

Participants Experiences with the TCLS and Discussion Sessions

In order to determine the experiences of participants with the TCLS and the discussion sessions, data were examined from interviews, web site counters, TCLS questionnaires, and discussion session questionnaires. From this data, experiences of participants and non-participants with the TCLS and discussion sessions were studied in more depth. In particular, we will examine the TCLS components used during the semester and the reasons for using them. We will end this section by looking at class attendance for participants in the study compared to students who did not attend the discussion sessions.

TCLS Components Used during the Semester and Reasons for Using Them

Quantitative Results. During the course of the spring 2005 semester web site hit counters for each component were recorded daily in an Excel spreadsheet. These counts represented a total daily count of how many times people went to that particular component during a given day. Table V shows the total number of hits each component had during a particular week during the spring 2005 semester. Examining the total weekly number of hits and the total number of hits during the spring 2005 semester, we see that on the surface the Learning Assessment Measures, LAMS; was used the most by far, with a total of 591 total hits. The second most used component was the Quick Algebra Reviews, QAR; with a total of 191 hits. This is followed by the how to study math, the how to use the TI-83 calculator, the Quick Trigonometry Reviews, QTR, and the application from engineering technology component with 141, 136, 127, and 58 total hits, respectively. Now if we examine the total hits for each component in a little more depth we will find that this is not, in fact, the correct ranking order. The website counters were provided by http://gostats.com website and provided different features that allowed the researcher to examine the website hits in more depth. For example, the gostats website allowed the researcher to see daily, weekly, and monthly bar graphs of the total number of hits for each component. In addition, the website showed the number of hits that came from search engines. The search engines included, but were not limited to, www.yahoo.com and www.google.com. These hits are more than likely from people that are searching for help from different math courses and the researcher believes that to get a more accurate total hit count, the hits that came from search engines should be deleted. The website showed that the following number of hits came from search engines for each component: the how to study - 7, QAR - 73, how to use the TI-83 calculator - 58, applications to engineering technology - 0, LAMS - 0, and QTR – 12,. Therefore a more accurate total hits count for each component is shown in the last column of Table V under Adjusted. We observed in the spring 2005 semester, that the LAMS component is the most used, followed by the how to study mathematics, QAR, QTR, how to use the TI-83 calculator, and the applications to engineering technology component.

Table V

Weekly Hits Counter for Each Component of the TCLS

components of TCLS	Total hits on TCLS website for week #																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9***	**10**	**11**	**12**	**13**	**14**	**15**	**16****	**Total**	Adjusted
How to Study	26	21	18	9	1	0	0	6	0	0	13	3	0	25	12	7	141	134
QAR	54	9	19	10	13	15	8	13	5	10	18	1	4	2	0	10	191	118
CALC	13	3	11	7	13	4	3	8	0	2	19	9	4	11	23	6	136	78
APPL	15	9	7	0	0	1	0	10	0	0	0	0	5	1	10	0	58	58
LAMS	45	87	82	17	49	40	28	24	4	21	35	34	41	15	47	22	591	591
QTR	24	31	5	15	4	8	0	15	6	4	2	7	0	3	1	2	127	115

*spring break week ** final exam week

Qualitative Results. The interviews were analyzed to determine which components participants used during the spring 2005 semester and the reasons for using those components. During the long interview participants were asked about what resources they used during the spring 2005 semester. Out of the 22 interviews, 20 were participants throughout the semester and 2 were non-participants. Both non-participants stated that they did not use the website and 15 out of the 20 participants (75%) interviewed stated that they used the website, but several stated that they did not use it very frequently. The interviews revealed that all 15 used the LAMS, 5 used the QARS, 3 used the how to use the TI-83 calculator, and the other components were used by 1 of the participants.

Responses from the TCLS questionnaire were used to examine the reasons why participants and non-participants used the TCLS and the interviews were examined to determine the reasons why participants used certain components of the TCLS. Twelve students who had used the TCLS during the spring 2005 semester completed the TCLS questionnaire. The reasons stated on the TCLS questionnaire for using the TCLS were the following, with the number of students choosing this choice in parentheses: getting a higher grade in the class (8), I heard it was helpful (8), learn the course material better (10), it helped when working assignments (11), I feared that I might fail the class (5), and other reason (1). The other reason that a student stated was that it helped with understanding the process of solving problems.

During the interviews students talked about how they used the different components, but they were not asked directly about the reasons they started using the TCLS. Although students did not comment directly about their reasons for using the TCLS, they did talk about the different uses of the TCLS components. Many students used the TCLS to help them work through assignments or to better learn the course material; these uses of the TCLS help us to better understand why students used this website. These uses reiterate two of the reasons why students used the TCLS that appeared on the TCLS questionnaire. In addition, Isaac states that one of the reasons that he started using the TCLS was because of a low exam score; he stated, "I had just been doing my old routine. For some reason I felt confident enough with it going into the first test. The first test was kind of a wake up call [for me], I did very badly on [it]" (9: 137 – 138). This adds another reason why students started using the TCLS. Finally another reason that Alex, Neal and Rachel started using the TCLS was that it helped them review their algebra and correct mistakes.

Reasons for Either Not Using the TCLS or Not Using the TCLS Very Much

Quantitative results. Responses from the TCLS questionnaire were used to examine the reasons why participants and non-participants did not use the TCLS and the interviews were examined to determine the reasons why participants did not use the

TCLS in more depth. Twenty-three students who did not use the TCLS during the spring 2005 semester completed and returned the TCLS questionnaires. The TCLS questionnaire had 6 statements in which the respondents had to answer with a response on a Likert scale. The Likert scale was from strongly agree = 4 to strongly disagree = 0. The first statement was I did not use the TCLS because I didn't need the help in this class. The results for question 1 are shown in Table VI with an average response of 1.500 and a standard error of 0.314. NR in the table stands for no response.

Table VI

Question 1 Results from the TCLS Questionnaire

Response	NR	4	3	2	1	0
# of students	1	3	3	4	4	8

The second statement was I did not use the TCLS because I could not find the necessary time. The results for question 2 are shown in Table VII with an average response of 1.091 and a standard error of 0.245.

Table VII

Question 2 Results from the TCLS Questionnaire

Response	NR	4	3	2	1	0
# of students	1	1	2	3	8	8

The third statement was I did not use the TCLS because it didn't seem helpful to me. The results for question 3 are shown in Table VIII with an average response of 0.450 and a standard error of 0.185.

Table VIII

Question 3 Results from the TCLS Questionnaire

Response	NR	4	3	2	1	0
# of students	3	0	1	1	4	14

The forth statement was I did not use the TCLS because I heard it wasn't helpful. The results for question 4 are shown in Table IX with an average response of 0.182 and a standard error of 0.084.

Table IX

Question 4 Results from the TCLS Questionnaire

Response	NR	4	3	2	1	0
# of students	1	0	0	0	4	18

The fifth statement was I did not use the TCLS because I didn't know about it. The results for question 5 are shown in Table X with an average response of 1.714 and a standard error of 0373.

Table X

Question 5 Results from the TCLS Questionnaire

Response	NR	4	3	2	1	0
# of students	2	5	3	3	1	9

The sixth statement was I did not use the TCLS because I didn't have access to a computer. The results for question 5 are shown in Table XI with an average response of 0.455 and a standard error of 0.225.

Table XI

Question 6 Results from the TCLS Questionnaire

Response	NR	4	3	2	1	0
# of students	1	0	3	0	1	18

Qualitative Results. The students were also asked if there were other reasons for not using the TCLS and they responded with the following responses:

1. I didn't know about it until the last of the semester.
2. I have a mid "A" in the class and just don't need help.
3. I forgot about it.
4. I simply didn't know about it.

A more in-depth examination of the reasons why participants either did not use the TCLS or used it in a limited role was provided through qualitative data collection and analysis. Data analysis was conducted on 20 interviews from participants in the study and 2 interviews with non-participants.

There are many reasons given which explain why participants did not use the TCLS or used it in a limited role. Some participants in the interviews did not either see a need to use the TCLS or misunderstood exactly what kind of help one could get from the TCLS. For example, Elliot stated, "my reasons were that I just really forgot about it [learning supplement]. I wrote it [website address] down at the beginning of the semester, but I thought it was an algebra review. I didn't really understand that it was all this other [stuff]. I didn't really know about it, it was never talked about in class" (5: 133 – 136). Quentin who participated in the interviews but was not a participant in the discussion sessions, stated that he remembers the researcher talked about the TCLS at the beginning of the semester, but did not see the need to use it until the course became harder. By then he had forgotten that the TCLS was available. He stated,

> yes I heard about it [TCLS]. I was aware from the very beginning of the semester. The beginning of the semester was fairly easy, it was review to me. So I didn't need anything, I didn't really look at the book even to do the problems. But towards the end of the semester when it [class] got harder, I completely forgot there was an online deal or I would have probably would have tried it. That is just my fault not looking at my notes (17: 101 – 104).

Quentin went on to say "I thought about it [TCLS] a couple of times and something would come up or I would be like well I just do the homework and just work on it a little bit longer rather than go to that because I need to go do some other stuff" (17:109 – 111). Valerie, another non-participant, simply did not even think about looking at the TCLS because she felt that she was doing well in the course. In addition, she makes the comment that not many others in class, at least the ones around her, talked about it either. She commented,

> I remember you talking about it [TCLS] when you first came in, but yeah I didn't realize … I mean I guess I didn't think about it because I didn't really need it. But I didn't remember it [TCLS] being there … people just didn't use the online as much as they used these [discussion sessions]. I didn't really hear anybody talking about it so I didn't really think about it (21: 89 – 93).

She did say “I wrote the [TCLS] address down but I didn’t think about going to it and looking at it” (21: 95). Alex, a participant, reiterated that other students in the class might not have known about it when he stated “I am not sure as many people know about it [TCLS] as you know … I think a lot of people heard you say something about it at the beginning of class and they think, oh yeah, that will be great and then they start thinking about other subjects or don’t follow through” (1: 258 – 261). Oliver adds a little more to this with the statement, “a lot of people didn’t take advantage of the fact the study sessions were there. So they didn’t gain access to the website and all that good stuff” (15: 120 – 121).

Another reason for not using the TCLS, or limited usage, was because the discussion sessions provided, in the participant’s opinion, better help. Kendrick responded to the question, were you aware there is an online learning supplement available for this course with “yes, you made that clear the first day. I didn’t feel the need to use it [TCLS] until I started coming to the sessions. I would rather use the sessions because I can talk about calculus” (11: 114 – 116). Oliver agreed with Kendrick’s statement when he remarked “there was a lot of stuff on there and yeah in the study sessions we did look at it a lot and that was a good thing. I got to use it during the study sessions and I didn’t really feel like I needed to look at it anymore” (15: 120 – 121). He also added “honestly I did not use it [TCLS] at all outside of the study sessions, but when we were in the study sessions we would go through it and I would use it” (15: 78 – 79). Gregory added “I think that I looked at it [TCLS] the first week, the week before the discussion sessions started. I felt that in the sessions … I was getting enough out of the tutoring to where I could go home and practice the problems on my own without needing additional help" (7: 138 – 140). Finally Dalton, a participant that started attending the discussion sessions later in the semester, remarked "I did not know about the website until last time we met which was last week" (4: 145 – 146). Some participants either felt comfortable using the TCLS and the discussion sessions, or simply did not need any help from the TCLS because the felt the discussion sessions was all the help that they needed.

Computer issues were other reasons for not using the TCLS outside of the sessions. Fred inserted during the interview "I am not a very big computer person and I don't have the internet at my house. If I was going to use it [TCLS], I would have to go to the library. If I was going to do that, it would be just as easy to pull out the book and go through the problems that we have already worked, [and] try to work [the problems] on my own" (6: 124 – 127). Oliver added "when I did do my homework, I wasn't at a computer because I seemed to get more distracted on the online stuff" (15:81 – 82).

Other participants had no time to use the TCLS or just time to use the LAMS component of the TCLS. Henry used the LAMS extensively during the semester but "didn't have time to look at it [other components] and maybe I just need to focus on what is on hand" (8: 141 – 142). Isaac said he had "a lot of time constraints with my other classes. That is probably the only reason, if I had more time to devote then I would definitely go look at it [TCLS]" (9: 189 – 190). Isaac goes on to say "I am one of those people that learns best when I am actually working one on one with someone. Actually hearing what someone says and actually working through it myself on paper. If I am looking something that someone else has written and I am just looking at that, it is kind of like almost like reading a foreign language sometimes, especially if I don't get it as well" (9: 177 – 181).

Some of the other participants voiced other reasons. Like Henry, Lincoln just used the LAMS component of the TCLS, but would have at least looked at the QARS if he had realized it was there. “I really never paid attention to the other things. I mean probably for the quick study of algebra, if I would have noticed that it was there, I have used that and I never knew the study for a test was on there” (12: 104 – 106). Mary stated that she did use the TCLS, but needed to be more consistent in using it. “I have gone to the website but I haven’t been consistent, however on some of the easier sections where an example has been worked out step by step, it has helped me a lot” (13: 110 – 111). Gregory admits that he should have used it more in other areas. “I did not really feel like it … maybe I should have in other areas and I would have done a little better than I have. With the sessions and the practice I was doing on my own, I felt like I was learning more” (7: 125 – 127). Finally Casey admitted that he was just lazy when responding to why he didn’t use the TCLS. “Lazy, I would rather do other things” (3: 85).

Reasons why Students Attended the Discussion Sessions

Qualitative results. Responses from the discussion session questionnaire and the interviews were used to examine the reasons why participants attended the discussion sessions during the spring 2005 semester. There were 13 students who attended the discussion sessions during the spring 2005, and who completed and returned the discussion session questionnaire. In addition, during the interviews participants explained why they chose to attend the discussion sessions.

One of the reasons why students chose to attend the discussion sessions was to help them make a better grade in the course or help with their G.P.A. Brett remarks that he attended the sessions “because I wanted to keep my G.P.A. up. Even though, I guess, a D would be passing, it still brings down your G.P.A. So I needed to keep it high for scholarship reasons” (2: 298 – 300). Gregory adds that grades are important to him and that he intended, before the semester started, to get help somewhere when he asserted “I care about my grades and want them to be as good as they can, so I knew from day one that I was going to look for some tutoring here on campus and take advantage of it” (7: 205 – 208). Jeremy and Neal agreed when they answered the question about why they attended the discussion sessions, with the statements “because I worried that I might not make a good enough grade in here. I knew I was going to need the help” (10: 266 – 268), and “to better my grade so I could pass this class and get down the road” (14: 240), respectively. Two other participants did attend because of grades, but the reasons went a little deeper. Grades were important to Mary, however getting help with homework was an additional reason for attending. “I knew [that I needed to attend] because I needed it to pass the course. I can’t afford not to pass it. And to get my homework done every week, to make sure I got it done right, and I wasn’t off on some tangent making up new math” (13: 265 – 267). Timothy’s reason why he attended the discussion sessions was “to grasp the concepts and to get a better grade, to get the “A” I wanted” (20: 190). Lincoln, Patrick, and Stephen agreed with Mary that getting help with homework was a big reason why they attended. Patrick stated, “I came to the discussion sessions to basically clarify the homework. To make sure I understood; it was like a second opinion to make sure I knew what I was doing” (16: 45 – 46). Lincoln and Stephen commented that “the help I got for my homework [is why I came to the discussion sessions]” (12: 210), and “I knew it would improve my scores and it helped me remember the material" (19: 252 – 253), respectively.

A more general reason why students attended the discussion sessions, that relates to understanding the homework, is to understand the material in the course. Casey, Elliot, Oliver, and William all stated that the reason they attended was because it help them understand the course material. Elliot responded with the course

> until the first exam, was mostly college algebra review and really wasn't that difficult. I could comprehend [the material] pretty well. Then we got into the actually calculus part of it and I understood but I really wasn't for sure of it. So I figured I better come here [sessions] and make sure that I learned it. Once the course got harder and harder I didn't understand that much at all, so I had to come here to understand it (5: 189 – 193).

Isaac stated that he attended the discussion sessions to get help with his homework so he could actually get it done and in order to make sure he understood the concepts. He states that "sometimes I would do the homework and it wouldn't reinforce the lecture and I would still have no clue on what I am doing and still be confused. Coming here actually took that part out, by the time I got done doing homework, I totally knew how to do it and I understood every reason why, every step. I owe a lot to the extra problems we did" (9: 272 – 278). Oliver states that "I just saw myself in class not really understanding the material, just because this is all new to me. When I couldn't get it in my notes, I went to the MLRC. Then I decided to try it [sessions] out and it was very helpful and I definitely have learned a lot from the discussion sessions" (15: 220 – 223). William added "I wanted to make sure that what I thought I understood; was in fact [what I was] understanding. I think that was my main emphasis for me going to the discussion sessions. [It was] just another way that I was getting everything that I should be getting from the class" (22: 423 – 426). Finally, Casey replies to the question about the reasons he attended with "there was a time when I knew I had to understand what was going on. I wasn't going to pass the class and then I got a handle on it and I was doing ok. Then I kind of lost the handle, but I was to busy to come to the sessions" (3: 158 – 160). For these participants, getting better grades, raising their G.P.A., getting help with the homework, and understanding the material in the course were the reasons why they attended the discussion sessions.

Although Casey reveals that he attended the sessions to understand the course material that he was having difficulty with, he also admits another reason was "just to study because I do not study on my own and it kind of gives me a set time to study" (3: 136 – 137). Fred had another reason why he attended. "At the first whenever you came to class and mentioned it [discussion sessions], it seemed like a good deal because I had an hour gap. Without the hour, I would probably be wasting it anyway. So [I] might as well get the extra help. Soon as I started coming it was almost becoming a necessity. If I didn't come [to the sessions], I fell far behind" (6: 185 – 188). Dalton and Isaac attended because they had low exam scores. Dalton thought he understood the material, "then after I got the first test, I thought well, ok, I did not know it. So I started going to the MLRC and overheard … I did not know about the discussions and stuff … overheard a guy talking about it in class and that was the first night I showed up. I believe it was a Tuesday and [I] showed up that night and liked it. So I have showed up ever since then"

(4: 204 – 208). Isaac had continued with the same routine that he had used in previous math classes and felt confident going into the first test, but "the first test was kind of a wake up call, I did very badly on [it]. I saw how useful they [discussion sessions] were [and said] wow I definitely have to tap this resource" (9:138 – 139; 214 – 215). Finally, Henry really didn't want to fall behind in class. "I didn't want to fall behind in class. I think … just trying to keep on top of things. Practice, stay on top of it. I did not want to get behind [in the course]" (8: 323, 324, 326) was the reason Henry stated that he attended the sessions.

Reasons why Students Did Not Attend the Discussion Sessions

Qualitative results. Responses from the discussion session questionnaire and the interviews were used to examine the reasons why participants did not attend the discussion sessions during the spring 2005 semester. There were 19 students that did not attend the discussion sessions during the spring 2005, who completed and returned the discussion session questionnaire. Also, 4 students who came to the sessions during the semester, but quit attended the sessions sometime during the semester gave reasons why they quit coming to the sessions. Although, 2 of these 4 students only stopped for a time during the semester, they were attending the discussion sessions at the end of the semester. During the interviews two non-participants explained why they chose not to attend the discussion sessions and why other students chose not to attend the discussion sessions.

Probably the most common reason for not attending the discussion sessions was because students felt that they did not need the help. This included the following statements from the questionnaire:

1. I didn’t attend the session because I felt as though I could either learn the material on my own or learn what I needed to know from the instructor by attending class regularly.
2. I didn’t need any help.
3. I never really needed any help throughout the semester right now I have an A in the class.
4. Because I have a medium “A” in the class and felt like I didn’t need help. Plus I took Calculus AP in high school.
5. I never attended the sessions because I understood the material I didn’t think I needed help.
6. I was doing well in the course and I didn’t really need the help. I also wasn’t always available to attend the discussion sessions.

Another prominent reason was that they forgot about the sessions or the sessions were at inconvenient times, as seen in the following comments:

1. I work nights and the sessions were either offered during my class or when I was working.
2. Forgot when and where they were held when I needed help.
3. I forgot about them and the times were not that convenient.
4. I had many things to do and forgot about them often.
5. For, bad times, working, and lazy.
6. I forgot all about it.

Several students stated other reasons for not attending the discussion sessions included:

1. I went to the MLRC.
2. My sister is a calculus teacher, so I did not need to.
3. I was busy with other things.
4. Didn't want to (attend).

The students who attended the discussion session, but for one reason or another quit coming to the discussion sessions for some time, explained why they quit coming, with the following comments on the questionnaire:

1. I attended the discussion sessions initially to help acclimate myself back into college level mathematics. After I started recalling some of the mathematics I learned in high school (over 10 years ago), I felt my knowledge was sufficient to continue to do well in the course without the aide of the discussion sessions. (this student came for the first month or so and quit attending after that)
2. I had difficulty taking time off work to come to the sessions (this student attended for a week or so)
3. I needed help for the class and I had heard from friends that it was helpful when I attended the discussion sessions they were very helpful in relaying the material to me. I missed the last few sessions due to conflicting schedule. But without the discussion sessions I wouldn't have made the progress that I have made in the class. (This student quit coming for a short period of time near the end of the semester, but attended prior to the final. The researcher did not official label this student as one that stopped attending the sessions.)

4. I was afraid I would fail with it. After spring break I had to take care of my niece and nephew and can't afford too much daycare so I had to stay home because my husband had to work because he is our primary income provider. (This student quit attending the discussion sessions after the second exam, but started attending again the week before finals. The researcher did not official label this student as one that stopped attending the sessions.)

Valerie did not participate in the discussion sessions until the last two sessions before the final exam in the class. The reasons that she gave for not attending the sessions during the semester were because she was doing real well in the class and didn't need the help. The researcher asked Valerie to comment on the discussion sessions and Valerie said "if I could do it over again, I probably would come to the discussion sessions." (21: 104 – 105) Valerie stated that the discussion sessions were helpful, because of "the problems that you gave us" to work on. "The extra problems that we had to do and make us apply what we were going to have on the test." (21: 182 – 183)

Quentin, the other non-participant that the researcher interviewed, really misunderstood exactly what the discussion sessions were all about. The misunderstanding that Quentin had, in his words, was because "I figured it [discussion sessions] was more expounding on the actually stuff that we did in class, like more explanation … like a lecture session." (17: 123 – 124) Quentin explained further, "I just figured if it [discussion sessions] was a study session then it would be like … like most of [the] other classes where we are going to have a study session the day before the test in the evening and if you guys want to come. All it is if you have questions he [instructor of other class] will … you talk to the professor and it is basically another lecture." (17: 128 – 131) After coming to the last few discussion sessions, Quentin stated that “I understand now it wasn’t a lecture, it was a group thing” and he said he would tell others to come and that he should have come.

Where and When do Students Use the TCLS During the Semester

Quantitative Results. During the course of the spring 2005 semester web site hit counters for each component were recorded daily in an Excel spreadsheet. Table V shows the total number of hits each component had during a particular week during the spring 2005 semester. The researcher examined the daily counts for each component to determine: (1) which day(s) each component was used the most by students, and (2) at what time(s) during the semester each component was used more extensively. In addition, the researcher will examine where physically participants said they used the components by examining the responses on the interviews. The researcher recorded 106 days of counts for each component between January 18, 2005 and May 7, 2005.

Examining the “how to study math” component, the researcher found that on April 22, 2005, 15 students visited this component. The next four days with the most hits were on January 18, 2005 (first day of class), February 1, 2005, March 30, 2005, and May 2, 2005 with 15, 15, 13, and 12 hits, respectively. In contrast, there were 83 days (78.3% of the time) with no hits at all, 5 days (4.7% of the time) with only 1 hit, and 13 days (12.3% of the time) with between 2 and 10 hits on this component. To examine how much the how to study component was used near the time of an exam, the researcher examined the number of hits the how to study component received 3 days prior and 3 days after each exam. For section 1, there were 45 hits (42.5% of the time) near exam dates and for section 2, there were 46 hits (43.4% of the time) near exam dates. If the researcher extended the time to 4 days prior and 4 days after the exam, then the use increases more than 10%. For section 1, there were 57 hits (53.8% of the time) 4 days prior and after each exam, and for section 2, there were 64 hits (60.4% of the time) 4 days prior and after each exam. In addition, there were 26 hits (24.5%) in the first week of class.

Table XII

Weekly Hit Counts for the How to Study Mathematics Component

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Hits that week	25	19	21	9	1	0	0	6	0	0	13	3	0	23	2	19
% of total hits	17.7	13.5	14.9	6.4	0.71	0	0	4.3	0	0	9.2	2.1	0	16.3	1.4	13.5
Standard error (%)	3.3	3.0	3.1	2.1	0.7	0	0	1.8	0	0	2.5	1.2	0	3.2	1.0	3.0

Turning our attention to the “Quick Algebra Review (QAR)” component, the researcher found that the QAR component was visited the most on the first day of class with 40 hits. The next four days with the most hits were on August 21, 2005, March 30, 2005, May 5, 2005, and 4 other dates with a tie for the number of hits with 8. Those ties occurred during the month of February at the following dates: February 1, February 14, February 20, and February 24. Table XIII shows the week by week hit total for the QAR. The QAR had been visited over half the total by the fifth week and almost three-fourths the total by the ninth week. By the eleventh week the QAR had been visited over 90% of the total number of visits.

Table XIII

Weekly Hit Counts for the QAR Component

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
hits that week	57	9	21	2	21	15	8	13	0	15	18	1	3	3	0	10
% of total hits	29.8	4.7	11.0	1.0	11.0	7.9	4.2	6.8	0	7.9	9.4	0.5	1.6	1.6	0	5.2
Standard error	4.2	1.9	2.9	0.9	2.9	2.5	1.8	2.3	0	2.5	2.7	0.6	1.2	1.2	0	2.0

Examining the "how to use the TI-83 calculator" component counts the researcher found that this component was visited the most on three different days, January 21, 2005, March 29, 2005, and May 2, 2005 with 9 hits on each day. The next three days with the most visits were on March 8, 2005, April 1, 2005 and May 5, 2005, with 7, 6, and 6 hits, respectively. The weekly hit total for this component is shown in table XIV. Half (50.0%) of the hits occurred after week 10 and the most weekly hits occurred during the first week.

Table XIV

Weekly Hit Counts for the How to Use the TI-83 Calculator Component

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
hits that week	20	4	11	6	10	8	3	8	0	2	18	7	3	15	14	15
% of total hits	13.9	2.8	7.6	4.2	6.9	5.6	2.1	5.6	0	1.4	12.5	4.9	2.1	10.4	9.7	10.4
Standard error	4.0	1.9	3.0	2.3	2.9	2.6	1.6	2.6	0	1.3	3.7	2.4	1.6	3.5	3.4	3.5

The "applications from engineering technology" component was the least used component of the TCLS. This component was visited the most on March 10, 2005. The next four days with the most visits were January 26, 2005 with 5 visits, April 12, 2005 with 5 visits, and three dates, February 1, 2005, April 26, 2005, and April 30, 2005, with 4 visits each day. Over half of the visits to the application of engineering technology component occurred before week 4 (see Table XV). Examining the daily counts for this component we find that there were 88 days (83.0% of the time) with no hits at all, 7 days (6.6% of the time) with only 1 hit, and 11 days (10.4% of the time) with 2 or more visits. In addition, more visited happened during week 1 than any other week during the semester.

Table XV

Weekly Hit Counts for the Applications of Engineering Technology Component

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
hits that week	13	10	7	0	0	1	0	10	0	0	0	0	5	1	8	2
% of total hits	22.8	17.5	12.3	0	0	1.8	0	17.5	0	0	0	0	8.6	1.8	14.0	3.5
Standard error	5.5	5.0	4.3	0	0	1.7	0	5.0	0	0	0	0	2.7	1.7	4.6	2.4

The Learning Assessment Measure (LAMS) component was used the most by students in technical calculus than any other component. This component was visited the most on February 1, 2005 with 49 hits that day. The next four days with the most visits were on February 17, 2005, January 21, 2005, January 27, 2005, and January 25, 2005 with 36, 30, 30, 29 visits, respectively. Table XVI shows the weekly counts for the LAMS component. Over half of the total visits (54.3%) occurred before week 7. There were only 43 days (40.6% of the time) with no hits at all, 4 days (3.8% of the time) with only 1 hit, 38 days (35.8% of the time) with between 2 and 10 hits, and 21 days (19.8% of the time) with more than 10 hits.

Table XVI

Weekly Counts for the LAMS Component

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
hits that week	29	86	94	15	51	38	30	24	0	25	22	42	43	15	29	43
% of total hits	4.9	14.7	16.0	2.6	8.7	6.5	5.1	4.1	0	4.3	3.8	7.2	7.3	2.6	4.9	7.3
Standard error	0.9	1.5	1.5	0.7	1.2	1.0	0.9	0.8	0	0.8	0.8	1.1	1.1	0.7	0.9	1.1

The last component, the Quick Trigonometric Review (QTR), had the most hits on the first day January 18, 2005 with 19 hits. The next four days with the most hits were on January 29, 2005, February 14, 2005, March 11, 2005, and January 25, 2005, with 14, 14, 13, and 8 hits, respectively. Almost half of the hits (47.2%) came in the first three weeks. There were 75 days (71.4% of the time) with no hits at all, 9 days (8.6% of the time) with 1 hit, 17 days (16.2% of the time) with 2 to 10 hits, and 4 days (3.8% of the time) with more than 10 hits. The weekly counts for the QTR component are shown in Table XVII.

Table XVII

Weekly Counts for the QTR Component

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
hits that week	22	26	12	1	18	7	1	15	0	10	1	8	0	3	1	2
% of total hits	17.3	20.5	9.4	0.8	14.2	5.5	0.8	11.8	0	7.9	0.8	6.3	0	2.4	0.8	1.6
Standard error	3.5	3.8	2.7	0.8	3.3	2.1	0.8	3.0	0	2.5	0.8	2.3	0	1.4	0.8	1.2

Qualitative Results. The participants who used one or more components of the TCLS were asked during the interviews where (physical location) they used the components of the TCLS. There were 15 participants who stated that they had used the TCLS during the course of the semester. The breakdown of where participants used the TCLS was: 10 used it at home, 10 used it during discussion sessions when either individuals or groups were working on problems, 3 used it at the library, 3 used it at other computer rooms on campus, and 1 used it at work. In addition, 3 students stated that they would basically use the TCLS anywhere that they had the chance to use it. The following are a few of the responses of the participants on where they used the TCLS.

1. I used it at the library on the desktops that they have there. I have used at my house on my desktop and I have used it at the library on the laptops that you can check out. I have used it up here in this room (room we used for the discussion sessions). (Alex) (1: 144 – 146)
2. Mainly in my room on my computer. But sometimes I would be at the library and I would jump on a computer, just when studying the section. (Brett) (2: 80 – 81)
3. I used it a lot where I live. (Lincoln) (12: 92)
4. At home or in one of the labs. (Mary) (13: 142)
5. At my work, that is where I have access to it. So I would use it there or drive to Stillwater and use it at the Math lab. (Neal) (14: 91 – 92)
6. I used it at home a lot of times at night when I would be reviewing and doing homework. Then on campus between classes, I would go to it and review stuff that I needed to. (Rachel) (18: 146 – 148)

Utilization of the TCLS

Qualitative Results. Participants who used the TCLS used the components in different ways. The LAMS component was used the most, followed by the how to study math, QAR, how to use the TI-83 calculator, QTR, and applications of engineering technology. In this section we will look at the uses for the LAMS, QAR, and other 4 components by looking at comments from the interviews.

We begin by looking at how participants made use of the LAMS component. One of the major uses of the LAMS was to aide the participant while working the homework. The LAMS component is broken up into two parts. One part is selected problems from each chapter in the technical calculus textbook by James Washington, and the other part is detailed solutions to those problems. The researcher intended the LAMS to be used in a way that students would first work out each problem on the LAMS by themselves, and then compare their solution with the detailed solutions. The participants did not use the LAMS component in this way. A lot of participants used the LAMS to help with the homework once they got stuck on a problem, or they used the LAMS to check their work on a particular type of problem. For example, Alex commented that sometimes he got stuck on a problem and he would use the LAMS component to help him solve the problem. Alex states "the way that I use the [LAMS] component again is to check my work or if I am stuck on a problem, I can go look through a couple of different problems that the discussion leader has worked out [on the LAMS] and maybe it will spark something and it will help me out" (1: 167 – 169). Henry agreed with Alex, but stated how he would go directly to a particular section, when he remarked "if I don't understand 5.3, then I will stroll through there and find 5.3 [on the LAMS], go to the solutions and look at how it is done" (8: 126 – 127). Henry reiterated this with the comment "really if I stumbled across a question, I would go to a LAMS section, find a problem like it on the same section, see how it is done and try to apply it to the problem that I am stuck on" (8: 154 – 156). Mary also used it similarly when she remarked "well when I had a homework assignment and I got to a problem that I was stuck on, I would look at the examples [on the LAMS] and see if there was one that was similar to it and see if I could use that example to help me solve the problem that I was working on" (13: 135 – 137). Jeremy would use the LAMS when he made a mistake on a problem. He stated "if I could not figure out my homework problem I would go look and see how one was worked on there [LAMS] and try to figure out where I messed up or what I messed up on" (10: 116 – 117). Timothy, like Jeremy, also utilized the LAMS when he made mistakes on the homework. Timothy stated that he would "go through the problem and go through the steps as it is shown on the LAMS, and see possibly where I made a mistake or what exactly I need to be doing" (20: 78 – 80). Lincoln used the LAMS at times when he did not attend the discussion sessions and also used it on problems that he was not able to solve. He missed quite a few sessions, but commented that "if I knew I wasn't going to make it to the review session, I would go on there and just find the most similar problem to what I am having problem with and just look how [the LAMS] did it. And then I would go along with how the [LAMS] did it on a piece of paper with the problem that I am doing" (12: 85 – 88). Patrick stated "for me when I looked over the LAMS, I knew somewhat going into it what was going on. But it seemed like I couldn't finish a few things, and if I can't finish it, then I will look over the solutions and say that is the final product [solution], now how are they getting it [solutions on the LAMS]" (16: 219 – 222). These were statements underlying the use as examples to follow as an aide when working on homework.

The LAMS were not always used to aide when working the homework. The LAMS were used when studying for exams. Furthermore, the LAMS modeled how the homework should be written up. For example, Henry talked about how the LAMS helped with the exams and modeled how the homework should be worked when he said, “basically, it [LAMS] contains what we will see on the test. It [LAMS] contains a problem and it shows the work and if we do not show the work on the test we will get counted off. It [the LAMS] is very clear; the scan homework on there as far as what steps to take. It is easy to follow, not only do you show the steps, but you say why you did it or you did this because of the rule or whatever. It is just easy to follow” (8:132 – 136). In addition, two students commented that the LAMS helps answer questions so that the instructor did not have to answer the questions or the student did not have to go to the discussion sessions to get questions answered. This can be seen by two statements by Henry and Stephen. Henry remarked, “I believe it [purpose of the LAMS] is to answer our questions so that you don’t have to answer it up here [in the discussion sessions]. You know it is still a small personal group, but if you have four people and you are helping someone else then look it up online and see if you can follow it. Maybe you can answer you own question” (8:132 – 136), and Stephen’s commented, “the purpose of the LAMS would be in case you weren’t in the discussion or at a class where you could talk to the professor, it did give some examples on how to get through problems for different sections of the work” (19: 91 – 93). Finally for each of the exams, students were allowed to bring in a sheet of paper, either 8.5 inches by 11 inches or 3 inches by 5 inches, with formulas and outline of concepts to help with the exams. A few students admitted that they included examples from the LAMS on the sheets of paper because they showed how to use the formulas and concepts from the class. Lincoln and Rachel were two of the several students that commented about using examples from the LAMS component on their help sheets for the exams. Lincoln stated “I would go through the LAMS and take examples from them and put on that half sheet of paper that we can take with us and use those" (12: 122 – 124), and Rachel added, "some of them [LAMS examples] I would use on my cheat sheet, the little sheet we got to bring in, because I knew that they were right and I understood them" (18: 270 – 272). The general consensus was that the LAMS were extra examples to those presented in the class and the book.

Therefore the LAMS were used to: 1) aide when working homework, 2) help study for exams, 3) demonstrate how the homework should be written up, 4) serve as a substitute for the instructor or for the discussion sessions by answering questions for a student who is working on his or her own, and 5) construct a help sheet with examples from the LAMS that were used for an exam.

Another component that a few students utilized was the how to study math component. The web hit counters showed that the how to study math component was the component that students used the second most of all components. A few students commented about the how to study component during the interviews. Rachel remarked "I think it is great advice on how to study for math, but for some reason, it was really good, but I just couldn't make it work for me for some reason. I have read it in books and everything and I went to it before each test trying to review. This is, what I need to do to make this test better than the last time. I think it is common sense that students sometimes need to have for reinforcement" (18: 120 – 124). She went further saying, "I think it just gave me that basic advice that I needed to hear to refresh my memory because for some reason math tests are difficult for me and maybe others" (18: 153 – 154). Neal said that the how to study math component "gives you some pointers, good ideas, and techniques on what you should do" (14: 102 – 103). He went on to describe how he tried to use the techniques. "I started looking at each problem, if I didn't know how to do it, I would go onto the next problem and get the ones knocked out that I knew. Then come back later and hash out the ones that I didn't know" (14: 113 – 116). Here it appears that Rachel kept going back to it with hope that she would find help where as Neal found some ideas that worked for him.

The last components that students talked about were the QAR and how to use the TI-83 component. Rachel states "it gave me a review, in some of my courses we did use a calculator, and just showed me stuff that I forgotten how to get to and some graphing and stuff like that" (18: 229 – 230). She also talked about the QAR component. "It is sort of like a crash course or a refresher, because once I hear it, all of a sudden I remember oh yeah that is how you do it. So when I forget something or how to do something, I would go to it, because it kind of embarrassing to say I forgot basic algebra. So it is easy when you have a website to go to and look it up" (18: 183 – 185, 169 – 171). Patrick stated that the QAR was the key for him in the course. "I found those things and that is what I focused on. I think that may have been a beginning key for me … I think I needed to figure out what I was doing wrong on those steps" (16: 178 – 180). Alex thought the QAR was the most helpful component for him because the QAR gave him "a basis to know" everything else and if he didn't understand algebra then he would "be sunk when it comes to test time" (1: 210, 213). He went on to say "I think the biggest thing [about the QAR] is for me knowing the areas that I am weak in, and being able to click on whatever area I need to become more proficient in and having that there available" (1: 127 – 129). Alex, after some review of algebra at the beginning of the semester and work throughout the year, improved his algebra skills. Alex, who went through college algebra four times before he successfully completed it, stated "one of the best ways to correct my mistakes, I found, was going onto the website and looking under the quick algebra review. After you gave us the pretest … the test with the little algebra review you gave us in class … and I found out that I got a 10 out of 20, I think I realized I needed to do a little work in that field. So I went to the website and that is where I learned algebra" (1: 47 – 51). He went on, after his algebra review during the semester, to say "I think that I have become extremely proficient in algebra" (1: 135 – 136). Brett did not go in as much depth but commented "I actually use that website … you can go to parts of it [to] review algebra so that you don't make dumb mistakes when it comes to algebra" (2: 30 – 31).

In What Ways the TCLS Helps with Technical Calculus

Quantitative results. Responses from the TCLS questionnaire were used to examine the ways the TCLS helped students learn technical calculus. The interviews were used to go into more depth on how the TCLS affected students. Twelve students who used the TCLS during the spring 2005 semester completed and returned the TCLS questionnaires. The TCLS questionnaire had 6 statements to which the students responded using a likert scale. The Likert scale was from strongly agree = 4 to strongly disagree = 0. The first statement on the questionnaire was "using the TCLS helped me increase my exam scores." The results are shown in Table XVIII with an average response of 2.833 and a standard error of 0.322.

Table XVIII

Question 1 Results from the TCLS Questionnaire for Participants

Response	4	3	2	1	0
# of students	4	4	2	2	0

The second statement on the questionnaire was "using the TCLS helped me understand the course content." The results are shown in Table XIX with an average response of 3.5 and a standard error of 0.261.

Table XIX

Question 2 Results from the TCLS Questionnaire for Participants

Response	4	3	2	1	0
# of students	8	3	0	1	0

The third statement on the questionnaire was "using the TCLS has helped me improve my study skills for this class." The results are shown in Table XX with an average response of 2.667 and a standard error of 0.225.

Table XX

Question 3 Results from the TCLS Questionnaire for Participants

Response	4	3	2	1	0
# of students	2	4	6	0	0

The fourth statement on the questionnaire was "I have used the TCLS outside of the regular discussion sessions." The results are shown in Table XXI with an average response of 1.667 and a standard error of 0.349.

Table XXI

Question 4 Results from the TCLS Questionnaire for Participants

Response	4	3	2	1	0
# of students	1	2	3	4	2

The fifth statement on the questionnaire was "using the TCLS helped me obtain a better grade in the course." The results are shown in Table XXII with an average response of 3.50 and a standard error of 0.230.

Table XXII

Question 5 Results from the TCLS Questionnaire for Participants

Response	4	3	2	1	0
# of students	8	2	2	0	0

The sixth statement on the questionnaire was "using the TCLS helped me pass the class." The results are shown in Table XXIII with an average response of 3.167 and a standard error of 0.322.

Table XXIII

Question 6 Results from the TCLS Questionnaire for Participants

Response	4	3	2	1	0
# of students	7	1	3	1	0

Qualitative Results. A more in-depth examination of the ways the TCLS helped with technical calculus was provided through qualitative data collection and analysis. Data analysis was conducted on 20 interviews from participants in the study.

We begin by looking at the ways the QAR component was used by participants. The QAR component was composed of 8 topics in algebra that were deemed the most used in technical calculus. Alex and Rachel, two participants who used the QAR extensively during the semester, stated that one of the ways in which the QAR component was helpful in technical calculus, was that it refreshed or helped brush them up on algebra at the beginning of the semester in technical calculus. Alex expressed that he had to refresh his algebra to work problems in technical calculus with the comment "I would figure out what I am doing wrong [on a problem]. So I would have to refresh on my algebra and say there is something here that I am missing and the [QAR] would allow me to do that" (1:138 – 140). Rachel said that the QAR component helped her brush up on algebra because a year had elapsed since she had taken college algebra. “I need it [QAR] immensely because it has been a year since I took algebra. I didn’t take algebra all that seriously, which I probably should of [have]. I knew I should of [have] when I was taking it” (18: 201 – 203). Another way the QAR component helped students was by helping students correct algebra mistakes. Brett states that “I knew that when I was doing the problems, the algebra just felt weird, did not seem right. That is when I would get on the website and just kind of correct myself with the algebra” (2: 73 – 76). Alex not only used the QAR to refresh his algebra, as stated before, but he also uses the QAR to correct mistakes when he made them. He illustrates this with the comment “one of the best ways to correct my mistakes, I found, was going onto the website and looking under the little algebra review” (1: 47 – 48). He continues that “once you are brushed up on algebra … you know … algebra becomes second nature” (1: 204 – 205). Rachel adds that she likes seeing the examples on the QAR and it “helps in the long run” (18: 189) more than the general rules. Finally, Stephen says that the QAR component “helped out the most part with algebra. I have taken algebra classes, but for some reason algebra is one of the hardest things for me to understand” (19: 147 – 149). Not only were the QAR components used for a review of algebra, but also as a way to correct mistakes.

The LAMS component, the most used component on the TCLS, was very helpful to students in learning technical calculus. The utilization of the LAMS was discussed in the “Where and when do students use the TCLS during the semester” section and included that the LAMS were used to: 1) aide when working homework, 2) help study for exams, 3) demonstrate how the homework should be written up, 4) serve as a substitute for the instructor or for the discussion sessions by answering questions for a student who is working on his or her own, and 5) construct a help sheet with examples from the LAMS that were used for an exam. This outlines the ways the LAMS components were used by students in technical calculus. The data suggested there are several other ways the LAMS helped students in technical calculus that might be related to the uses stated above.

One way that the LAMS helped with technical calculus was that the LAMS gave students more examples of worked-out problems. William reflected in his interview, "there are only so many good examples in the book, there are only so many examples that you can work out in the book and have a good answer to in the LAMS" (22: 273 – 275). Kendrick expressed that "it is kind of like seeing it on the solutions manual, you see how things are worked and by seeing visually and looking at it, you can develop an understanding of why to do this and how" (11: 68 – 70). Rachel added "I think it [LAMS] has contributed to my understanding a lot. I just remember it. When I look at it [LAMS], I can say oh I get that, I understand that" (18: 355 – 356). For these students the LAMS are helping with understanding a topic.

Another way the students said that the LAMS helped with technical calculus was by showing them step by step solutions. Lincoln asserted that by seeing step by step solutions for problems in the LAMS, he understood the steps needed to solve the problems. He states, "it [LAMS] really helped me just learn how to go through my stuff step by step. I would like know what steps to take on each problem" (12: 97 – 98), and Stephen added "the website gave a break down and why it was that way" (19: 187 – 188). Timothy agreed with both Lincoln and Stephen and adds that the LAMS gave him extra practice, when he notes "it [LAMS] has given me the extra practice and extra steps or building blocks to help me to understand the concepts" (20: 123 – 124). William used the LAMS at the beginning of the semester to reinforce the concepts of conic sections and derivatives. He illustrates this when he expressed "the LAMS were good at the beginning just again to reinforce the ideas that were being presented that again I hadn't seen in a long time" (22: 264 – 265). Students thought their understanding was increased by seeing detailed solutions and by getting extra practice.

In What Ways do the Discussion Sessions Helps with Technical Calculus

Qualitative Results. Qualitative data collection and analysis was used to examine the ways the discussion sessions helped with technical calculus. Data analysis was conducted on 22 interviews with students. 19 of these interviews were with participants who attended the discussion sessions throughout the semester, while the remaining 3 with 1 participant who attended the discussion sessions but stopped attending after the first month in class, and 2 students who did not attended the discussion sessions throughout the semester, but attended two discussion sessions during finals week.

The discussion sessions helped students with technical calculus in different ways other than simply by helping them with their homework. Participants communicated through the interviews that one of the major ways that the discussion sessions helped with technical calculus, was in clarification of the concepts. Brett illustrated this with "I would also come to the study sessions and review a bunch of the problems that we learned here. I could ask questions about problems and get better clarification" (2: 21 – 23). He reiterates this with, "it was just a small group study sessions, but it just really helped out with clarification and not being embarrassed about asking questions" (2: 278 – 280). Elliot went into a little more depth when he noted,

> as far as class, the instructor would present the material but he does it himself on the board. Most of the time it made logical sense how to do it, but you go home and you have your own problems and it is just like how did he do that. But when you come here [discussion sessions], you show us one or two and you make us do problems ourselves and we figure out the questions we have and we could ask you. I think we learn more from that, finding questions ourselves than if somebody just tells us (5: 216 – 221).

The discussion sessions helped Henry to understand the concepts by getting his questions answered. He states "It is nice to go over problems, numerous problems, where if you don't understand the concept or you don't understand the examples, you can bring in here and ask a question" (8: 102 – 104). Isaac says that the discussion session helps with learning technical calculus, not only with clarifying concepts, but also by providing extra practice on working problems. He comments

> usually in a math class I just focus on the homework. You know really I wouldn't go back and work any other problems. I would just do the homework. Coming to the extra sessions gave me the opportunity to get more practice, do more problems, maybe clarify anything that I hadn't … maybe clarify any misconceptions from lecture that I might have had from not doing something. It was very good and clearing everything up and organizing (9: 86 – 91).

He continues that the discussion sessions helped clarify the topics that were being discussed in the lecture with the remark that “there was a lot more confusion coming out of lectures. So it was so clear cut that is when I came to the sessions to clarify all of that” (9: 108 – 109). Lincoln adds “it [discussion sessions] has helped me understand what I am doing better, a lot better” (12: 200). Finally, Timothy suggests that during the discussion sessions, students can get clarification by getting a wide range of questions answered. He described this with the comment “well in class you don’t get to go in as much depth for each aspect of each section. Like you usually give us an example or two about … like some of the lower level problems, once you get to the homework you have more difficult problems and so coming to the sessions you get more wide range of questions that you get answers to. If we do have questions we can actually ask you” (20: 176 – 180). Casey states that the discussion sessions helped with course material because he could ask questions when he stated “you go to the discussion sessions and you can actually ask questions and if you don’t understand something and maybe it can be explained better than in class or on the internet” (3: 95 – 98). The key issues for these students were clarification and practice.

Another way the discussion sessions helped with technical calculus was in preparing students for exams. Alex’s statement demonstrates this when he mentions that the discussion sessions “helped me with my homework, completing it; it helped me prepare for tests” (1: 373 – 374). Elliot agrees, but states that the discussion sessions help him also work the homework and serve as a designated study time for technical calculus. He concludes that the discussion sessions “helped me a bunch. It really prepared me with what I needed on the test, and I got a general idea of how to do it in class. Coming here I would practice on it and it made me actually sit down here for an hour and a half to two hours and work on it. I didn't have to sit in my room and get distracted … you could sit down and learn it" (5: 171 – 174). The discussion sessions also helped Fred prepare for exams and in addition, helped him to keep up on the material and understanding the lectures. He states, "I started doing the sessions and then I would do the homework of that section usually after class. So I would be on top of the game before the next class and I would be up to date on all the material" (6: 15 – 17). He continues with it "kept me going on the right material and I didn't procrastinate and wait until the very last moment to do something" (6: 165 – 166) and "so when we started covering stuff, I knew exactly what was going on. I was pretty much ahead of the game. For the test I was well reviewed and came pretty prepared" (6: 222 – 224). The discussion sessions helped Patrick prepare for the exams by doing extra problems. He expressed this when he says "coming to the discussion sessions so that I could work out just other problems, not like the homework, but just other example problems. That way I go through the list that is similar to what is going to be on the test, 2 or 3 problems from each area of the test, then that basically is another form of reinforcement" (16: 60 – 63). These students thought they were better prepared for the exams, because the discussion sessions provided a quality study time that kept them from falling behind.

Several other participants mentioned different ways that the discussion sessions helped them in technical calculus. Dalton stated that "I did not pay a lot of attention to it [class] and I did not put a lot of effort into it either. As far as putting any effort to learn, I struggled with the first test. When I started going to help sessions and discussions and what not, it [material in the class] all came around to me a little better, once I started putting more effort into it [class]. I could learn, I did repetitions of problems, and since then it [class] has been pretty fun" (4: 11 – 15).Gregory added "I went into the lecture kind of knowing what to expect with already doing some examples. You know after you see a couple of examples ahead of time, and then see it again. You know what to expect, you know what is coming (7: 189 – 191). Henry commented, "I think the class, this has been really useful and I don't know, probably the single biggest reason that I am passing the class" (8: 395 – 396).Stephen stated "basically going through the problems slow and working it out while we are doing it on the board and talking about it just helps me remember a lot better" (19: 215 – 217). These students thought they were learning the material better by doing repetitions of problems, making the lectures easier to understand, and remembering the concepts.

Improving the TCLS

Qualitative Results. Qualitative data collection and analysis was used to examine how to improve the TCLS. Data analysis was conducted on 22 interviews, in which 19 of these interviews were with participants who attended the discussion throughout the semester, 1 participant who attended the discussion sessions but stopped attending after the first month in class, and 2 students who did not attended the discussion sessions throughout the semester, but attended two discussion sessions during finals week. In addition, data analysis was conducted on 12 TCLS questionnaires that were filled out by students that used the TCLS during the spring semester. The comments on the interviews were made by students based on their experiences with the TCLS, however the students' perception play a large role in the comments that they made during the interviews and on the TCLS questionnaires.

Students who used the TCLS and filled out the TCLS questionnaires were asked how they would improve the TCLS. Many of the comments from students when answering this question did not address how they would improve the TCLS, instead the comments dealt with how the TCLS helped them in the course. The few comments from the TCLS questionnaire that address the question were:

1. Remind students about it [TCLS] and explain its purpose.
2. Push it in the MLRC and have students tell students how it helped.
3. I would show everyone in the class how to use the system. I think that more people would be prone to take advantage of the system.

Students who used the TCLS and filled out the TCLS questionnaires were asked what they could do or say to get students to use the TCLS. The comments from the TCLS questionnaire were:

1. Possibly have some required homework problems on it. Also, remind students that it is available.
2. Continue to remind them about it. Make sure they know how to access it and any function it has.
3. Maybe remind them throughout the semester that it is there instead of just at the very beginning when the class is easy.
4. You might show percentages of people that use the system to the grade which they received.
5. Remind them about it and explain its purpose.

6. I would show everyone in the class how to use the system. I think that more people would be prone to take advantage of the system.

Several participants in the discussion sessions added more comments when they were asked how they would improve the TCLS during the interviews. Many of the participants said that they did not have any suggestions on improving the TCLS and were satisfied with the TCLS. Brett felt like maybe some more examples on the LAMS would help in specific sections when he commented "if something had to be changed, what it would be is another example, a few more examples" (2: 163 – 164). Lincoln sometimes would not understand the examples on the LAMS and get lost and so he remarked that the LAMS could be improved by being "more explicit on steps … sometimes I get lost" (12: 115 – 116). Quentin did not attend the discussion sessions nor use the TCLS but suggested that the researcher "remind students that the website is there because there are students like me that wrote down it [web address] once and forgot about it" (17: 257 – 259). Jeremy made the suggestion that he would improve "the calculator part because it is for the TI-83 and I know most people have different ones than that" (10: 147 – 148). Rachel suggested that a "practice test" (18: 301) be added to the TCLS. Finally William suggested that "having homework problems and saying this is similar to LAM 3.3 or something like that" (22:317 – 318) would be helpful.

A Look at Class Attendance of Participants and Non-Participants

Quantitative Results: Attendance records were examined for both participants and non-participants in technical calculus. Table XXIV shows the attendance for 18 participants who used the discussion sessions throughout the semester. Notice that

Quentin, Valerie, and William were not included because Quentin and Valerie were non-participants, and William attended the discussion sessions for only around a month at the beginning of the semester. The average number of days of class missed for participants was four days, and the average number of days of class missed by non-participants, along with Quentin, Valerie, and William, was 7.44 days. This calculation of 7.44 days did not include any non-participant that had withdrawn from the course or stopped coming to class.

Table XXIV

Number of Days Missed by Students who attended the Discussion Sessions

Participant	# of days missed in class	Participant	# of days missed in class
Alex	2	Kendrick	9
Brett	1	Lincoln	2
Casey	6	Mary	3
Dalton	1	Neal	3
Elliot	3	Oliver	2
Fred	9	Patrick	2
Gregory	1	Rachel	8
Henry	6	Stephen	2
Isaac	8	Timothy	8
Jeremy	0		

Pre and Post Algebra Assessment Data

Quantitative Data. The researcher administered a pre-algebra assessment to every student, who was in attendance on the first day in technical calculus during the spring 2005 semester. During the last week of class the researcher administered to all in attendance, the same algebra assessment as the post-algebra assessment (see appendix A for the algebra assessment). The pre and post test results are shown below in table XXV. The participants are shown in the table by their pseudonym and the two non-participants who interviewed with the researcher at the end of the semester are also shown by their pseudonyms. In addition, the two students who stopped attending the sessions altogether, are coded in the table as stopped 1 and stopped 2 (the other participant who stopped attending the sessions after the second week is not coded in the table). All other non-participants are coded in the table as non-participant with a number. The table lists sc = score, T1 = topic 1, T2 – topic 2, and so forth. The topics are listed in the methods section in table III.

Table XXV

Pre and Post Algebra Assessment

	Pre-Test								Post-Test							
STUDENT NAME	Sc	T1	T2	T3	T4	T5	T6	T7	Sc	T1	T2	T3	T4	T5	T6	T7
non-participant 1									8	3	1	0	0	2	1	1
Fred	15	3	2	1	2	3	2	2	15	2	3	0	2	4	2	2
non-participant 2	13	3	0	1	2	4	2	1	18	3	3	2	1	3	4	2
non-participant 3	11	3	1	1	2	1	1	2	12	3	2	0	0	2	3	2
non-participant 4	9	3	1	2	1	0	1	1								
Neal	11	3	1	1	2	3	0	1	10	3	1	0	1	1	2	2
non-participant 5	11	3	1	1	1	2	2	1	15	3	1	1	1	3	4	2
Casey	10	3	0	2	1	2	2	0								
non-participant 6		0	0	0	0	0	0	0								
non-participant 7	12	2	1	2	2	1	2	2	13	3	2	1	2	2	2	1
Stopped 1	3	2	1	0	0	0	0	0	10	3	1	1	1	1	1	2
non-participant 8	8	0	2	0	1	2	2	1	12	2	1	2	0	3	2	2
Lincoln	3	0	2	0	0	1	0	0	9	2	1	1	0	0	3	2
Jeremy	14	2	2	2	1	2	3	2	10	2	0	1	1	2	2	2
non-participant 9	17	2	2	2	1	4	4	2	15	3	0	0	2	4	4	2
non-participant 10	7	2	3	0	0	1	1	0	10	3	1	1	0	3	2	0
Mary	14	2	2	2	1	3	3	1	16	3	2	2	1	3	3	2
William	17	3	2	2	2	2	4	2	17	3	3	2	0	4	3	2
Brett	13	2	1	2	1	3	3	1	14	3	1	1	0	4	3	2
non-participant 11	12	3	2	1	1	2	2	1								
non-participant 12	13	2	2	2	2	1	2	2								
Stopped 2	4	1	0	1	1	1	0	0	11	3	1	0	2	3	1	1
Henry	13	2	3	1	1	1	3	2	16	3	1	1	2	4	4	1
Elliot	10	2	2	1	0	2	2	1	13	3	1	1	0	3	3	2
non-participant 13	10	1	1	1	1	1	3	2								
Isaac	17	3	3	2	2	2	3	2	16	3	2	1	2	3	3	2
Rachel	9	3	1	1	1	2	0	1	13	3	1	1	2	3	2	1
non-participant 14	8	1	1	1	0	2	1	2	15	3	2	2	1	3	3	1
Patrick	10	3	2	0	1	1	2	1	9	3	1	1	0	0	4	0
non-participant 15	8	3	2	0	0	0	1	2	8	3	2	0	0	0	1	2
non-participant 16	6	3	1	0	0	1	0	1								
Stephen	8	2	1	0	0	2	1	2	8	2	1	0	1	1	2	1
non-participant 17	11	2	2	1	1	1	2	2	10	3	0	1	0	2	4	0
non-participant 18	13	3	3	1	2	1	1	2	14	3	1	2	1	2	4	1
non-participant 19	9	3	2	0	0	1	2	1	6	2	1	0	0	0	3	0
non-participant 20	10	3	3	0	1	1	0	2	5	2	0	1	0	0	1	1
non-participant 21	8	3	1	0	2	2	0	0	10	3	1	1	1	1	2	1
Kendrick	9	3	0	1	1	2	2	0	13	3	1	1	1	4	3	0

non-participant 22	9	2	1	2	0	2	1	1	12	3	2	1	1	1	2	2
non-participant 23		0	0	0	0	0	0	0	13	3	2	1	1	2	2	2
non-participant 24	9	3	2	1	1	1	0	1	14	3	2	1	1	2	3	2
non-participant 25		0	0	0	0	0	0	0								
Alex	8	2	2	1	0	2	0	1								
non-participant 26	9	3	1	1	1	1	0	2								
non-participant 27	7	3	1	0	0	0	2	1	11	3	2	1	1	1	3	0
Gregory	5	1	1	0	0	2	1	0	10	3	1	0	0	2	3	1
non-participant 28	5	1	0	1	1	1	1	0								
non-participant 29	6	2	1	0	1	1	0	1								
non-participant 30	9	1	2	2	0	2	0	2	11	3	1	2	0	2	2	1
non-participant 31		0	0	0	0	0	0	0								
non-participant 32	19	2	3	2	2	4	4	2								
non-participant 33	11	3	3	1	1	0	1	2	12	3	1	2	0	3	3	0
non-participant 34	13	3	2	1	2	1	2	2	14	3	0	2	2	2	3	2
Valerie	13	3	2	1	1	2	2	2	14	3	2	1	1	3	2	2
Quentin	8	1	1	1	2	2	0	1	10	3	1	1	1	0	3	1
non-participant 35	11	3	1	1	1	2	1	2	9	2	2	0	0	1	2	2
non-participant 36	11	3	1	0	2	2	2	1								
non-participant 37	5	2	0	2	0	1	0	0	12	1	1	1	0	1	2	1
non-participant 38	12	1	1	1	1	2	4	2	13	2	1	1	1	4	3	1
non-participant 39	5	3	1	0	1	0	0	0								
non-participant 40									8	3	0	0	1	1	1	1
non-participant 41	8	2	1	1	1	0	2	1	11	3	0	1	0	2	3	2
non-participant 42	9	3	2	1	0	1	1	1								
non-participant 43	8	2	1	0	0	1	2	2	8	3	2	0	0	1	2	0
non-participant 44	8	3	1	1	1	1	0	1	7	3	1	0	0	0	2	1
Dalton	8	2	1	1	1	1	1	1	12	3	2	1	1		4	1
non-participant 45	7	3	1	0	0	1	2	0								
non-participant 46	10	2	2	1	1	2	1	1								
Timothy																
non-participant 47	8	2	2	1	1	0	0	2								
Oliver	9	2	1	0	0	2	3	1	9	2	1	0	0	2	3	1
non-participant 48	14	3	3	1	2	0	3	2	14	3	3	1	2	0	3	2

Participants' Perceptions of the TCLS and Discussion Sessions

Difference in Performance With or Without the TCLS

In this section, how students felt they would be doing in the course if they didn't use the TCLS will be discussed. This will be followed by comments from students discussing the reasons for the differences in performance with and without the TCLS. Finally, student comments concerning the effect that the TCLS has had on their homework and exam performances along with their overall grade will be discussed

Several students felt that they would not have been successful in technical calculus without the help that they received from the TCLS. Alex states “I am not sure if I would even pass. I would either fail it [the class] or get a D; it [my grade] would be really, really low” (1: 289 – 290). Rachel adds “I would have failed for sure, or I would have dropped” (18: 363). Brett did not feel like he would have failed without the TCLS but said he would “probably have done a lot worse, maybe a D. I would say a D.” (2: 203) Mary states that without the TCLS, “I would have failed” (13:191). It is unclear if she interpreted failing with a grade of a D or an F because she says “I might have been a barely C, but the website had enough of an explanation to help me understand” (13: 193 – 195). She continues “using the program gave me a better understanding of how to work the problems and helped me to learn how to do it on my own. If I was unable to work the problems, then I would not have been able to pass the class” (13: 202 – 204). Neal remarks “I definitely would be doing a lot worse” (14: 178). Neal’s grade at the time of the interview was a grade in the D range, probably closer to a high D. Jeremy did not put as much emphasis on the TCLS when he communicated that he “probably would [have] a C average” (10: 191) if he didn’t use the TCLS and went on to say that he had a B with the TCLS. He did comment that the “TCLS [has] helped it [his grade] a lot” (10: 182). Stephen, like Jeremy, asserted that “if I didn’t use the website for any of this, I would probably be average, maybe a C” (19: 155 – 156). So students thought the TCLS helped them successfully pass the class or be more successful in the class.

The TCLS also helped students who were doing very well in the course. Patrick, who was making a strong A’s most of the semester on homework and exams, stated that the he would “probably not [be doing] as good as now” (16: 326) if he didn’t use the

TCLS. He continues and says that without the TCLS I "would probably say at least a high B or B. Judging on the website only, I might scrape for an A, probably, where now I am probably more comfortable" (16: 326 – 328). Finally, Timothy states that the TCLS has helped him increase his grade by around 3% and says "it helped, but I really think the sessions are what really helped" (20: 130). So it was not just the weak students who benefited.

Several students discussed why the TCLS has helped them improve their grades. Alex states that the difference in his grade with and without TLCS "would be that I would not have the supplement to go to and if I don't have the supplement to go to then I have more mistakes on my homework. More mistakes on my homework would mean lower quiz grades and all that boils up to lower test grades" (1: 301 – 304). Rachel talks about the TCLS helping when she quit coming to the discussion sessions. She doesn't discuss exactly how the TCLS helped her, but remarks that

> I relied upon it a lot I guess because after a while I wasn't coming to the discussion sessions and I have needed it; it has helped me maintain a hanging on kind of grade after I quit coming to the discussion sessions. Without it I wouldn't have anything. I have looked at the cliff notes and that is kind of vague and doesn't really help me that much. The TCLS actually just breaks down [the problems] for me and for me it helps me understand it (18: 370 – 375).

Mary stated that the TCLS "gave me a better understanding of how to work the problems and helped me learn how to do it on my own" (13: 202 – 203). Neal comments that the TCLS made a difference in his grade because "you didn't have to rely on an individual to be there all the time. If it was 2 o'clock in the morning it is there waiting on you. People that have busy schedules can benefit because it is at their disposal." Jeremy states that the TCLS made a difference in his grade "because it has a place where you can go reference anytime. Like the MLRC, they are closed or sometimes you have to work late, however you can always go to the TCLS and get help" (10:201 – 203). Stephen says that "seeing the material more and going over it as far as examples" (19: 163) has made the difference between him making a B rather than a C in the course. Finally, Timothy remarks that the TCLS helped his grade because the TCLS helps one with your homework tasks. He states that "if you miss a couple problems on every homework assignment then there is [overall] points that you miss" (20: 138 – 139). The students have several different reasons for how the TCLS is helping them.

Students didn't stop with commenting on the effects the TCLS had on their overall grade, they also mentioned the effect it had on their homework and exams scores. Alex states that "I think it [TCLS] has improved them [homework scores]. If I hadn't had the website, I would have had lower scores on them, and therefore I would have had more questions because I had more mistakes on my homework. So therefore, if I didn't get those questions corrected, then I would have more mistakes on my exams and lower grades. Hence [I would be] on the margin on getting through the class" (1: 265 – 269). Brett says "I definitely have some of the highest homework scores in the class. Just because I have used the website frequently compared to others that don't really" (2: 181 – 183). The TCLS not only helped him with his homework, it also helped him with his exams. This is seen in the statement that the TCLS along with the discussion sessions have "improved my exams scores a lot. When I started coming here, compared to some of my friends who don't come here, and I think it really shows a difference to when you use the website and come to the sessions compared to someone who doesn't" (2: 187 – 190). Henry admitted that the TCLS has helped with his homework, but didn't have a big impact when he expressed, "I have used it [TCLS] on my homework to get the stuff down. I wouldn't say it had a huge effect just because of the way I wanted to use it" (8:203 – 204). Jeremy states, "it [TCLS] has increased them [homework scores] quite a few points because at first I wasn't using it and then I got to where I could understand it" (10: 165 – 167). He continues to explain that the TCLS has helped increase his homework scores from the beginning of the semester, when he was earning "half to three-fourths of the full credit of the homework points" to a later time, when he was getting "almost full credit after he started using it" (10: 171 – 172). Also Jeremy says, "I haven't used it to study for a test, but since I knew how to do my homework better, then it increased my tests scores" (10: 176 – 177). Lincoln notes that the TCLS has helped him make better grades on both the homework and exams. He states that he would "probably have an average score of a D or C probably and my homework score is a C now" (12: 132 – 134), and "it [TCLS] has raised my exam scores. I have two B's and one C on exams. Probably raised my exam scores 10 to 15 total points; I mean it has really helped" (12: 138 – 140). Oliver asserts that the TCLS "raised my homework scores because you could see step for step what to do and on your homework you could follow those guidelines which would help you do your homework, which would cause you not to have errors in your assignments and dock you points for your grade" (15: 128 – 131). He continues "if I didn't use the website, I don't know how I would be doing in the class. Now I have a chance to earn a B in the class. As for when I first came to class … I just expected to pass the class. But now I have a chance to easily obtain a B" (15: 142 – 146). Rachel states that "I think there is a direct correlation between the TCLS and the discussions sessions, and my grades. Once I started not coming to that [discussion sessions] and not using the TCLS as much, you can see the correlation in my grade" (18: 334 – 337). Rachel was doing well until she quit coming to the discussion sessions and used the TCLS in a more limited role. At the time she quit coming, she was making B's and C's on assignments and exams, but after she quit, her scores on homework and exams dropped to C's, D's and F's. Stephen also believed that there was a relation between the TCLS and discussion sessions with his exam scores. He stated that

> I can tell it [TLCS] was a direct relation with my test scores. Whenever I was coming to the discussion sessions and everything, I understood everything and I was making 90's on my tests. And then one exam I didn't get to make it to a few discussion sessions and I didn't really understand the material. Needless to say that my test score was bad on that exam. I kind of see that as a direct relation because I think if I came I would have understood the material better (19: 113 – 118).

Finally, Timothy states that the TCLS has helped him make a little bit better homework scores when he says that the TCLS "has improved them [homework scores] a little bit and like I said, if I got stuck on some of the homework, I would use the examples [LAMS]" (20: 112 – 113). The help that participants received from the TCLS had a variety of impact on their homework and exam grades.

Difference in Performance With or Without the Discussion Sessions

In this section we will begin by discussing how students felt they would be doing in the course if they didn't attend the discussion sessions. This will be followed by comments from students discussing the reasons for the differences in performance with and without the use of the discussion sessions. Finally, we will end this section with student comments discussing the effect that the discussion sessions have had on their homework and exam performances along with their overall grade.

Several students felt the discussion sessions helped them earn better grades in technical calculus. The students' comments ranged from the discussion sessions helped them stay in the class to comments that the discussion sessions helped them increase their grade in the course. Casey, a student who had attempted the course several times without being successful, stated that the discussion sessions helped him improve his exam scores. He states that "I don't think that I made over a 40 on a calculus test" (3: 153) in previous attempts at passing the course. During the spring 2005 semester, Casey had two exam scores, a 79 and 50, that were higher than the 40 that he said he never achieved before. Henry admits that "if it weren't for the discussion sessions, I would probably be withdrawn right now. It has made a huge difference" (8: 308 -309). Isaac also felt like the discussion sessions have helped a lot with the comment that "I probably wouldn't be in the class right now because I would have failed it" (9: 124). Rachel, who quit coming to the discussion sessions after the second exam because of family obligations, was also helped a lot in the course by the discussion sessions. She articulates that "the discussion sessions saved me, if I could have come the full time throughout the semester, I would probably have a B. I think an A would be pushing it, my math skills aren't that great"

(18: 14 – 16). She continues explaining how the discussion sessions saved her with the statement "I think without the discussion sessions, I would have never made it and would have dropped within the first week" (18: 16 – 17). Although Fred didn't feel like he would have dropped or failed, he estimates that the discussion sessions have helped him obtain a "mid C" (6: 71) and states that he "would be getting a D or F if he wasn't coming to the sessions" (6: 73 – 75). Gregory expresses that "if I didn't have the sessions, my grade wouldn't probably be as good as it is now. I would hope for a C and I am hoping my grade will be in the mid B range" (7: 84, 88 – 89). Therefore several of the students felt that their grades were improved by coming to the discussion sessions.

Participants were asked on the questionnaire what grade that they would expect in technical calculus if the discussion sessions were not offered and explain why. The majority of the comments expressed that without the discussion sessions, they would have a hard time understanding the material. The comments from the questionnaires were:

1. I would have probably failed.
2. Low C to D range if not worse.
3. Probably a C or D, just because I wouldn't have as good as understanding of the criteria.
4. B-; I would have not understood the material and would have been lost.
5. C, because without the sessions I don't think I would be able to understand all the material.

6. F; There are several times the material was not understandable and I wouldn't have been able to do the homework or tests. The MLRC is only good to a point; their skills as teachers are not present.
7. I would expect a B. The sessions just made the class easier to understand.
8. I would just expect to pass the class, but I have the chance to obtain a B.
9. Probably a C. I am not that good in math and I expected to make a C. I have a very good shot at an A now.
10. Most likely a C, because the extra 4 hours a week offered in these sessions were truly where I completely grasped the information. The extra practice was also most definitely a key.

Several students expressed why they thought the discussions helped them with the class. Dalton stated that there were several reasons why he started doing better in the class after a slow start for about a month. He expressed that one reason was

> me waking up and realizing that, 'hey, you have got a class to take care of.' That is one, and that is where you start. Two is when I started coming to the discussion sessions and putting out effort there. Doing problem after problem, after problem; studying the material. Basically putting out effort that is what it is in anything. If you are going to make a good grade or do what ever, you are going to have to put out some kind of effort. I will be honest with you. I did not put out anything the first month and a half. I did what I had to do to just get by and a D wasn't going to cut it. So I heard about it [discussion sessions] and I thought that would be great and I started going to the sessions. Since then it has really helped (4: 99 -108).

Elliot states that “coming into here [discussion sessions], I can understand why we are doing different aspects of it [a problem] and I will try to figure it out from there” (5: 87 – 88). He continues that he gets an “overall idea of how to work things” (5: 88 – 89). Fred states that the discussion sessions have helped because “we would go over the homework and all that so there wouldn’t be just points lost due to stupid mistakes. That is why, if I have the right problems and all that …, I can go back and study for the test and it makes it a lot easier” (6: 83 – 85). Gregory admits that the discussion sessions give him more confidence in his math ability. He communicates this by stating that the discussion sessions make a difference in his grade, “because I have more confidence on what is going on. When I sit down and take a math test, I don’t sit there and stare at it and wonder where to start and what to do first. I feel like my knowledge of calculus is just improved and I am not as lost” (7: 96 – 99). Mary voices that “for the first exam I came to some of the discussion session on the stuff I didn’t get. I did the homework all the time and I got an 84, I think an 89 after the curve. However, on the second one, the material got tougher and I was having problems doing it. Also I was only attending the sessions from time to time and I got a 68, 70 after the extra credit” (13: 280 – 284). She believes that if other students “come to the discussion sessions, get the extra help they need and come to the sessions before the exams then they will do a lot better. They [other students] will at least get a B in the class if not higher” (13: 234 – 237). The students think the discussion session helps by motivating them, increasing their confidence and keeping them on task.

Participants provided a little more depth, when they explained how the discussion sessions affected their homework and exam scores. The discussion sessions helped

Dalton to improve his homework and exam scores. He states that by attending the sessions, his “homework grades [went] up a ton. In addition, my second test was a 93 and I started going to the sessions after my first test, which I made a 68 on, … you can see how much it brought my tests up” (4: 185 – 189). Isaac did not start coming to the discussion sessions until after the first exam and believes that he would be doing even better in the class if he would have started coming earlier. He communicates this with the statement “I was like I have to utilize this resource because it going to do nothing but help me. I realized that early on, I probably would be doing a lot better. Probably I would have a B if I started coming before that first test” (9:139 – 141). Kendrick also didn’t start coming to the sessions until later in the semester and says that “the discussion helped me as far as the course. It improved my grade, maybe 10 to 15 percent because the lack of understanding [I had] on certain things and by going to the discussion sessions, it didn’t take long to show how it worked out” (11: 181 – 184). He continued, saying “I think that if I would [have] used it [TCLS] at the beginning more and come to the discussion sessions more, my first test would have been an 80. I would have probably literally got an A [in the class]” (11: 84 – 86). Oliver, a student who regularly attended the discussion sessions, stated that most courses start off easy at the beginning of the semester and becomes harder as the semester goes on. However, Oliver stated that wasn’t the case in technical calculus and gives the credit to the discussion sessions as to why it didn’t seem to get harder. He notes that “in most classes you are supposed to start off with easy then go to hard, therefore you would think your scores would drop off. But mine has been the opposite; it [homework scores] has started kind of low and as I have gone through the semester the grades have increased. So I would definitely advise them [other students] to go [to the sessions] and it is definitely helpful" (15: 170 – 174). Rachel remarks that there is a "direct correlation to my grade. You can see where I … when I was at the discussion sessions and when I wasn't. My grades were great and I understood it [course material] and I comprehended it. In fact, I will probably do better on the final on the parts where I was going to the discussion sessions than when I wasn't" (18: 439 – 442). Finally, we end with a comment from Mary about other people coming to the discussion sessions. She mentions that "if they come to the discussion sessions, do their homework, get the extra help they need, come to the discussion sessions before exams, then they will do a lot better and they will at least get a B in the class if not higher" (13: 234 – 237). These comments give a good testimony for improved grades.

A Look at the D-F-W Rate for Participants and Non-participants and Students Perceptions on their Success in the Course

As was stated in the background of the problem, D-F-W rate the past fifteen semesters has averaged 42.9% and ranged from 24.1% to 60.7%. During the spring 2005 semester the D-F-W rate was 38.9% for the whole class; however, only 10% of the participants received a D, F, or W. The two students, Casey and Neal, received D's in the course. Casey did improve since he had either failed or withdrew from the course twice before, and Neal would have successfully earned a C in the course if he would have passed the final. Neal, who was an adult returning student, was very busy working 40 to 50 hours a week. Not only that but he lived in a different town than the one where he worked and the one where the University was located. During the last few weeks of the semester, Neal decided it was too much work for him to make a C in the course because of the stress of studying and the demands of his workplace. The researcher believes that there would have been a good chance that Neal would have done much better on the final if he would have been as dedicated to his class as he was to his job.

With only 10% of the participants getting a D, F, or W, along with the fact that Neal could have obtained a C in the course, we find that students were very successful in the course when they used the TCLS and/or discussion sessions. However, the D-F-W rate for participants is not significantly less than the D-F-W rate for non-participants. The participants' perception on what grade they were making in the class with and without the TCLS is shown in Table XXVI.

Table XXVI
Grade Perception With and Without the TCLS or Discussion Sessions

Participant	w/o TCLS or discussion sessions	w/ TCLS or discussion sessions
Alex	D or F	B-
Brett	D	B-
Elliot	B	A
Fred	D or F	C
Henry	W	C+
Isaac	F or W	C
Jeremy	C	B
Lincoln	D	C or B
Mary	F	B
Neal	D or F	D
Oliver	D or C	B
Patrick	B or B+	A
Rachel	F or W	C or B
Stephen	C	B
Timothy	B	B+ or A

Students Recommendation to Their Friends Regarding the TCLS and Discussion Sessions

The researcher asked each student who interviewed with the researcher at the end of the spring 2005 to "describe to me [the researcher] what you would recommend to a friend, who is taking this course next semester, with respect to the discussion sessions and online learning supplement." The student responses to this interview statement, gives some insight on the participant's perceptions of the TCLS and discussion sessions at the end of the spring 2005 semester. They are not going to recommend something to their friends that they themselves do not believe works.

Alex made the following recommendation to a friend when he declared,

> I would tell them don't wait to the last minute. Start … if anything is rocky, if your base isn't solid, you are not great in algebra, or you are not confident going into this calculus class, then go to the sessions because they are very beneficial, they won't hurt you at all. And look up the website when you are doing your homework and have that as a facet to become more confident; become more proficient in working through your calculus problems (1: 345 – 350).

Brett communicated that he would tell a friend to "definitely to use it. First time they offer it [sessions], go to it and go to it as often as possible, because it will be difficult to try to get good grades in this course" (2: 245 – 246). Elliot expresses that since calculus builds on itself then he would recommend that a friend use it before they get behind. He interjects, "don't get behind and if you don't learn something then just don't say it will be all right and we will go on, because it [course] builds on itself. If this is here next semester then I would definitely tell them to come here. This is the only reason why I am doing as well as I am doing" (5: 139 – 140). Gregory says that he would tell a friend to

> just use both of them [sessions and TCLS] as often as you can. If there is ever a time that you don't feel confident about the class or your learning, then definitely take advantage of the tutoring sessions and the online learning supplement. It just makes the whole semester so much easier. You aren't struggling the whole time to keep up and even at times you can be some what ahead. So I would definitely recommend both to anybody (7: 168 – 172).

Henry would tell a friend to "come to the discussion sessions as much as possible. Definitely go to class, don't use this as a substitute. Go to class, attend as much as possible, especially near exam times. Probably utilize the TCLS more than I did" (8: 285 – 287). Isaac said "I would definitely suggest they would utilize both. They go to the discussion sessions as much as possible, even if they are not doing badly in the course. More practice never hurts. Even if I was proficient in this course, I would probably still have come to the discussion [sessions]" (9: 210 – 213). He continues with "a lot of times when there is extra help sessions, most of the time students get it in their head that it is just for students that are having trouble. If you actually go out and say even if you are doing well in the class, you get a 90, you may be able to get a 95 on your next test, no guarantees, but you get out of it what you put in to it" (9: 228 – 231). Kendrick concluded, "I would recommend going to the discussion session, because I really think that is the key. Because not just the context is really tough, but it helped [me to] better understand what everything is over. It just gave a little more support to make you do a little better” (11: 152 – 154). Neal says “I would tell them [friends] to definitely go to this group if you are having any kind of troubles. Unless they live and breathe calculus, they are going to need help, and that is a good supplement to use” (14: 200 – 202). Finally, Timothy states that he told a friend to go to the sessions but that friend didn’t and finally had to withdraw from the course. He says “I had a friend who was in the class with me and I was like, dude, go to the sessions. He didn’t go to the sessions and he had to drop the class, even if you are lazy and you have a hard time studying, this helps so much” (20: 207 – 209). Students either gave recommendations to fellow students to use the TCLS and discussion sessions or would have if asked.

Perceptions of the Three Step Method

The researcher used the three-step method to involve the students with the concepts of a particular section in the textbook. The three-step method consisted of reviewing a problem using the LAMS in a particular section, working another problem on the blackboard while the researcher asked students to help solve the problem by contributing in the problem solving process, and finally, having the students work one or more problems by themselves or in small groups. Once the students had worked the problems individually or in small groups, the researcher would go over each of the problems so that the students could check their solutions, and determine whether they understood the steps of the problem. In this section we will look at students’ perceptions of the three-step method.

We begin with a comment from Alex where he notes that the discussion session were different from the regular class and took some time to adjust to the three step method.

> Overall it [discussion sessions] was a lot to take in when I came into the first review session, because you had this website that you were using in conjunction with the blackboard … other students were making comments and talking a lot more than they do in class in this review session. I wasn't for sure which way to look or go; about fitting into this deal. But once you explained overall what we were doing as far as looking at an example online, work through an example with you, and then working on our own, it became more and more easy to fit in and feel comfortable (1: 464 – 472).

He went on to comment about the three step method. The three step method starts "with you kind of presenting us with a problem, letting us think about it for a few seconds, showing us a solution and then bringing up another problem and saying ok let us go ahead and work through this together. Then boom we have another problem that is similar and you say go ahead and do it, and half the time everybody in the class can do it" (1: 355 – 359). Dalton remarked on the ways in which the repetitions in the discussion sessions via the three step method helped him by stating, "I would go to the review sessions that we had and basic repetitions of problems, problem after problem after problem. That helped, going through the problems one by one. You will set up a problem, we will try to do it then we can look at you do it on the board, you explain it, and we can look at our [solution] and say, 'oops I messed up there or hey I did this one right'" (4: 39

– 41, 173 – 177). Gregory remarked exactly why the three step method is helpful by saying, “we do them step by step on the board. Then given a similar type of problem to do on our own, to make sure we understood what we just done on the board. It just gives an extra boost to make sure you understood what is going on and just very helpful.” (7: 176 – 179). Sometimes students understand the lecture, but when they get home they don’t remember how to work problems from a certain section or they thought it was easy, but the problems are harder than what they thought. For example, Mary has a hard time working problems because she forgets. She responds “[the purpose of the LAMS is] to show me how the problem is done. Give me an idea … I don’t remember how to work the problem after class and the steps show me the process that I need to do to solve that problem” (13: 129 – 131). She adds that she thinks the system is a good way of “making us do the work. You know you have an example, you know we go through them, you refresh our memory on how the process goes, then you make us tell you what the next steps are, and then at the end make us do problems on our own and then work through them as a class” (13: 241 – 244). Oliver suggests that the key to the three-step method is when the researcher works a problem and then the students would work through problems themselves. He states,

> I think just the fact that you would work a problem out and we would see how you would do it. And you would assign a problem for us to do and we would work through it. Then we would all go back and rework it just to see if we all came up with the same answer. I think that is the key, you get to see how to do a step, work through it together, and then give you a

> single problem that you can do on your own. It just becomes more natural (15: 178 – 183).

He goes on further with, "I think a lot of it would be just the process [where] you would work a problem and we could see you working it. We could visualize what exactly you are doing step by step and then you would shoot us a problem and we would have a chance to do it which I think is helpful" (15: 246 – 249). Rachel believes the whole process helps students build confidence when she states,

> I like to see one and well I kind of got it, and then when we talk you through it, then you hear it from other students, and for some reason it clicks in your mind. And doing it on your own … for a while there I called my dad and said wow I can do this calculus. So when I can do one after you said do one on your own and I got it right, I was like wow. It was a good feeling. I didn't think I could even pass this class (18: 418 – 423).

In one last comment from William, he gives an overall opinion on the three-step method. He comments,

> I thought it [three-step method] was a great way to do it because you were reinforcing … you were … instead of spoon feeding it by saying this is how you do it, it was alright look at this, how do you think it is going to be done. And then alright take this one and let's work through it together, but you were getting feedback from the audience as you were going and testing alright from what you got. I think it was a very good way to do it (22: 391 – 395).

So the students thought all three steps of the method were important elements in improving their understanding.

Overall Thoughts from Students about the TCLS and Discussion Sessions

In this section, we will look at the overall comments from participants on both the TCLS and discussion sessions. These comments were made by participants during the interviews and give an overall perception of what students thought about the TCLS and discussion sessions. We begin by looking at the comments participants made about the TCLS.

Alex stated that he relied on the TCLS the whole semester for help when he said “overall it has just made me more confident with how I step through problems. Like I say it has been kind of like my safety blanket throughout this whole semester” (1: 281 – 282). Brett commented that the TCLS was like a personal tutor when he remarked, “It was like a gigantic study guide/outline/solving problems, just … it was phenomenal how much it was like a little personal tutor” (2: 170 – 171). He continued with “it just clarifies what we are talking about” (2: 195 – 196) and “I thought it was great. I probably wouldn’t be passing if this system wasn’t around” (2:311 – 312). The only thing that Henry stated specifically about the TCLS was about how it covered a lot of material when he expressed, “I was pretty impressed with the thoroughness of it” (8: 186 – 187). Rachel remarked that the TCLS breaks down the problems and helps her understand, and states that students all over the world would benefit if courses had online supplements. Two other comments that show this are “the TCLS actually just breaks down [problems] for me and it helps me understand it” (18:454 – 455), and “I just wish some other courses would have something like that [website]. I think that it would help students all over the nation, the world, everywhere" (18: 97 – 98). Timothy makes a comment about the discussion sessions and the website when he says that the learning system is "everything you would want in a tutoring session. If you need to talk to a teacher and ask a specific question, it is there and if you have a simple question or you are missing a step, you can just look it up on the website" (20: 201 – 203).

As Timothy suggested the discussion sessions were an important part of the learning system. Dalton declared exactly how the discussion sessions helped him when he said that, "since I started coming to the sessions, I have learned twice as much as I learned the first month and a half [without the sessions]. I am still pretty vague on the stuff we did the first month and a half of class" (4: 222 – 225). Isaac went in a little more depth about the discussion sessions with

> I keep hitting on them a lot, but that goes to show you what a big part of this course it was and how helpful it was. But when we worked through problems we understood where our weak areas were and how to fix those. That is kind of the best thing. You are going through a piece of machinery and some part of it is not working, you go through each part, keeping the good parts and finding the one part that is bad. You want to replace that [bad part]; you want to fix it (9:306 – 307).

He continues with "this [sessions] actually helped with my success in the course. I mean it is going to help me actually pass the course, which I wouldn't have done with-out it. Just keep doing it because there are students out there that need it" (9:318 - 321). Kendrick furthered this by suggesting that the sessions would help improve grades of students when he declared, “I feel like if there were more classes that had discussion sessions type things, the grades would improve dramatically, because there are a lot of times that you don’t understand what went on in that class” (11: 216 – 218). Patrick thought the discussion sessions were somewhat like having a lab class for a course; “having the help sessions was kind of like having a lab almost” (16: 445 – 446). Rachel would not have grasped the material if it were not for the discussion sessions; she expressed, “it was the only way that I understood it [the material]. There was just no way that I could understand it otherwise” (18: 97 – 98). She adds “when I heard that there was discussion sessions [at the beginning of the course], I just thought, this is going to help me get through this course” (18: 454 – 455). Stephen agreed with Rachel when he stated “if I didn’t come to the sessions, then there is definitely no way that I would be doing as well in the class as I am right now. It helps out because going into calculus, I am probably going to remember everything, if not, mostly everything that we have talked about throughout the semester” (19: 271 – 274). Gregory voiced that “without it [sessions], I feel like I would have struggled more than I did and I am actually going to pull a decent grade out of calculus that I wasn’t expecting” (7: 14 – 16). Finally, Elliot, a student who had an easy time in high school math and both college algebra and trigonometry, said that “I have never needed a tutor type person to ever tutor me in math. It [sessions] was a new experience and I think it worked out really well and I have learned a lot coming” (5: 208 – 209). Overall participants had a very positive opinion about the TCLS and discussion session, and felt that the learning system was very instrumental in helping them be successful in the course.

Benefits Students Received from Participation with the TCLS or Discussion Sessions

Learning by Seeing Examples on the Website and Active Learning

The structure of the discussion sessions using the three-step method and students seeing example problems from each section on the LAMS component of the TCLS is different than what they experience in the lecture. The discussion sessions are centered around students seeing problems worked, students helping solve problems, and students working problems with a hands on approach. In this section we will look at what students say about seeing examples on the website and working problems by themselves or in groups, and how this helps them understand the technical calculus material.

When the instructor for technical calculus works examples on the board, some students see the instructor work the problems, but might not really understand the example. The student has not engaged his or her mind so that he or she understands the example that the instructor has presented. We have seen in a few comments in previous sections that students believe that they understand a concept in class, but when they get home they have troubles working the assigned problems. A few more comments came from Rachel. She said that "in class I pretty much understood what he was talking about in class, but when I would go and do it on my own, I would struggle" (18: 11 – 13) and "I think that when it [calculus] is explained to me, I understand it … it is so clear as day, but when I get to it on my own it is hard to understand" (18: 381 – 383). We will now look at students' comments from interviews about actually understanding examples from a specific section by working through problems themselves in the discussion sessions.

We begin with a comment from Alex; he says that the LAMS are invaluable because examples on the LAMS do not just show the solution but it also explains each step of the problem solving process. He states that on the LAMS,

> there is actual explanations as to where you go or how you derived your final answer and it leads you along step by step. This is invaluable to me because a lot time people will explain to you they are thinking about something in their head but they are not saying it out loud and therefore if they are saying it out loud, I am not hearing it. This doesn't make it any easier for me to accomplish a goal that I have set forth (1: 157 – 163).

Brett agrees with Alex by stating "it [LAMS] shows you the steps, the step by step of the equations, how they should be done or even how they should be thought about it in your mind. It is real simple, black and white, step by step ways of solving equations" (2: 92 – 95). Mary comments that she would rather see how to work problems by actively participating when she says, "I am more of a visual learner. I have to see how it goes to be able to do it. I am not a learner by listening … he can lecture all day long about theory and this is what the formula is, and I don't get it" (13: 87 – 89). Neal states that by having students work the problems, the students find out whether they understand the problems. He states "having us work them [the problems] draws our attention right to the paper. So it puts us on the spot and brings out whether we know the problem or not, and shows where our weakness are at" (14: 209 – 211). Oliver remarks that the TCLS and discussion sessions "are a great way to learn, just by seeing it and then by trying it yourself. Eventually you are going to get the hang of it and do it on your own" (15: 239 – 241). Rachel says that the three-step method helps her remember; "for me if I see it, hear it, and write it, then I remember it. For me as an older student I have to do a lot more than some of the other students do. I have been out of school for over 12 years now" (18: 53 – 55). Alex states that the sessions are great at building confidence so that he can go work problems on his own when he states, "I think coming to these discussion sessions and practicing these problems four to six hours each week really gives me a big jump because then I can go back and I get pumped up when I get out of this review and that night I look at more calculus …" (1: 309 – 311). Finally, Kendrick would rather the technical calculus lecture be more like the discussion sessions when he remarks, "you have to understand that the degree that I am in is interactive hands on, and so that is how I see things. And by having a class like that, yeah I think it would be really good" (11:203 – 205).

Flexibility of the TCLS

The TCLS was a learning supplement that was developed to help students be more successful in technical calculus. Before the TCLS was developed, students who sought help with technical calculus had to seek help through a private tutor, academic services, MLRC, classmates, friends, solutions manual, another internet website, or other resources. Students who use one of these resources, for the most part, can not have access to it anytime of the day. However, students can get help from the TCLS anytime of the day and any day of the week. Many of the participants cited that being able to get help at anytime is important to them. Alex talks about using the TCLS anytime to help him work on weak areas in algebra when he states that "knowing the areas that I am weak in and being able to click on whatever area I need to become more proficient in" (1: 127 – 128). Brett comments that, "basically it [TCLS] is like a tutor that is available 24-7. I can go to it and look up any type of an example, or type of chapter, or section" (2: 51 – 52). He continues with, "it helped me out, it made things quick and easy. Instead of having to call someone up or walk all the way across campus to talk to a TA, I could with a couple of clicks and there I would be" (2: 85 – 87). Henry notes that the TCLS is available when students are not in the discussion sessions or the discussion session leader is not there to help in the problem solving process. He states, "it [TCLS] is another easy way, once we have left this room (room the discussion sessions were held in) or even if we are in this room, if you are not there, we can just go on the website, we have it just the way we need to solve it. You know, easy practice method and convenient, get on the internet and study. I definitely think it has had a positive effect" (8: 209 – 212). When Jeremy could not find any other help, the TCLS was available. He stated, "if I had a question I guess I really didn't have much other help, but I could always get on there, anytime" (10: 131 – 132).

In describing the effect the TCLS had on his exam scores, Neal stated, "It gave me something to go back and look at. That is one real nice thing about it. You didn't have to rely on an individual to be there all the time. If it was two in the morning it is there waiting for you. People that have busy schedules can benefit because it is at their disposal" (14: 170 – 173). Rachel agreed with Neal with a very similar comment; "It helped me out any time I got stuck and I was able to refer to it any time I need help, you may be at home and it is 2 in the morning and you are doing homework, and you have that access to it [TCLS]. It is set up really well where it is easy to use. I think it was just great" (18: 282 – 283, 313 – 314). Finally, Timothy talked about the extra experience working through problems that the TCLS provided at any time of the day with, "it [TCLS] just added that extra practice. I mean it was there if I needed it, like if I didn't get everything accomplished that I needed to in one of the sessions, and I needed to be shown like a step or so or something. It would really help me out" (20: 102 – 104). Flexibility was a very important aspect for some of the participants.

Changing Students Mathematics Attitude, Increase in Confidence, and the Ability to Finish Problems Because of the TCLS and/or Discussion Sessions

Students have said that the TCLS has helped them in various ways. Some students have also said that they have had a change in attitude because of the TCLS and discussion sessions. Some students reference a change in the way that they worked the homework and other students referenced that the interaction in the discussion sessions effected a change on their math attitude. Alex made statements several times during his interview with the researcher about how his attitude towards mathematics has changed. He begins with the statement, "[discussion sessions] showed me a different way [to] kind of look at how I was going to accomplish what I set out to accomplish on the homework" (1: 25 – 26). He continues to talk about how he and other students think about the homework in the past and how this mentality for him has changed:

> The mentality that I think a lot of students, and myself … I catch myself doing it … you will see something in class, like an example and they think

> that is so easy … no problem I really don't have to study it much. Do my homework, bam boom, it won't take me to long. But I have found that you can't really start your homework to early, there is no … you will perceive it one way … you will think another way when you start you homework. Just because you get your homework done does not mean that you understand … it means your homework is done. In order to understand something you need to go back two, or three, or four more times, and do the same problems again, and again, and again, before you actually understand it, I think (1: 430 – 439).

Recall that Alex had a lot of trouble with college algebra. He had to take college algebra four times before he was successful and adds, "I have failed math classes in the past and I know it is because, you know, I have not put enough effort and time into it and I did not want to make that mistake again" (1: 391 – 393). He reinforces that there has been a change in the way he thinks about the homework when he states, "I think what has made the difference is just me sitting down and not thinking, ok I have to do this homework as fast as I can, but me sitting down and saying that I have to do this homework right. I just kind of opened my mind up recently and I am not fighting it. I can do the algebra a little bit easier … [I have been] doing it so long now, it is just second nature" (1 418 – 422). His final comment sheds a little more light on how he goes about working the homework compared to how he worked homework in college algebra; "Now I work through my homework two or three times. I will erase a problem and do it six times before I am completely happy. If I think that there is one mistake with it, I will erase it until I am completely happy, or I will ask my professor after class, or I will ask in the discussion sessions. If I second guess any of my problems then I usually say something" (1: 444 – 448).

Alex wasn't the only student who commented that they have experienced a change in their attitude towards mathematics. Henry stated that "I would have to say that the class [technical calculus] got me thinking a little more than any other math class, probably because a lot of it is new. I seem to have taken a little bit more pride [in my performance], especially since it seems realistic for me to obtain a B in this class" (8: 119 – 121; 238 – 240). He explains why he has had a change in math attitude. He remarks

> the opportunity is open for people to definitely achieve a high score which probably … if they would realize that, they might put a little bit more work into [the class] themselves, instead of I am going to get a C or D and pass it. But probably I am taking a little bit more pride in math, because my resources are there and will help me understand it. Also if it is not as confusing, I will probably like it more. That seems like the whole point of coming to the discussion sessions. They make it less confusing and little more understandable and more natural to you (8: 240 - 246).

Several students commented that the TCLS and discussion sessions helped to improve their confidence in math and their ability to finish problems. For example, Alex said the QAR helped him understand algebra, which would "allow [him] to finish his problem and in the end be confident about the answer that he got" (1: 152 – 153). His confidence in his ability to understand technical calculus shows in the following response; "I talk to them [other students in the class] about it [TCLS], people will be jealous that I don't have a cheat sheet, a formula sheet or whatever for the test. The other students say 'I guess you know how to work them out don't you', and I look them in the eye and say I sure do I know how to work every single problem and that feels good …" (1: 383 – 386). Henry adds to this when he states, "I feel I am more able to reach that higher score with the resources available. You know also the fact I know there is less of a reason for me to get a lower grade. I have all these resources, so there is no excuse for me to get a C or a D in the class" (1: 153 – 156). Kendrick states that he is motivated by the discussion sessions to learn, with the remark, "coming here is going to make you want to learn more" (11: 273 – 274). Isaac, Mary, Patrick, and Stephen talk about how the TCLS and discussion sessions helped them before and during exams. Isaac had trouble looking at the LAMS because it was hard to understand all the steps and recognize what is being used, but "before the test, if I am looking at something like that, I am a lot better at recognizing all that" (9: 181 – 184). Mary agrees with other students who said they were more confident going into an exam compared to other students they knew. Mary adds, "I know I have left here [discussion session] being absolutely confident that I could ace this test coming up" (13: 259 – 260). Patrick states that the discussion sessions help prepare him for the exams when he comments that he received "help through the sessions, [and that] the reinforcement from it has made the difference in being ready going into the test. Just being confident in myself to doing the homework and knowing what is going on" (16: 346 – 347). Stephen remarks that the three-step method helps with preparing for exams with the comment, "I think it has all to do with it because you are not worrying, you are calm, and your mind is more clear. Your pretty confident that you know what is going on, you are not really stressing out about the material" (19: 231 – 234). He continues talking about taking exams while he was attending the discussion sessions and when he was not attending; “I know the first two exams, while I was coming to the discussion sessions, I was a little anxious, but other than that I was pretty calm and it didn’t effect me. The last exam that I had taken, I was a little bit stressed out because I didn’t know the material and I was kind of flustered. I would work through a problem that I did know, but I couldn’t really think about it, I couldn’t get my mind right” (19: 237 – 241).

In preparing for the exams students worked homework. Patrick and Stephen talked about the discussion sessions and TCLS helping them be more confident when working homework. Patrick states, “the TCLS has definitely given me a lot more confidence on the homework and helped me solve through a lot of stuff, which was good for me and kind of helped me work through the homework a lot better” (16: 302 – 304). Stephen adds to this with, “I feel a little more confident and more able to do the homework. It is not such a hassle because you are not stressed out all the time” (19:228 – 229).

Finally, Oliver states that he feels good about being successful in technical calculus by using the TCLS and working problems in the discussion sessions. “I think that it has been challenging. For a lot of people math is not their subject, but this is the most challenging subject for me. I know, which I think that is kind of interesting just because something that you put effort into and you get feedback, you know it makes you feel good about yourself when you do good stuff. So I just feel like it was a good learning system you know, I have learned a lot from this class” (15: 151 – 155). Stephen adds, “this is probably one of the first classes that I have actually understood everything from the beginning of the year up to this point at the end. It seems like I remember more from the first and second week of school than I would in another class" (19: 168 – 170).

Other participants commented on what changes have taken place with respect to other previous mathematics classes. Some of these changes are due to the TCLS and discussion sessions. These changes are changes with respect to how students did things in a previous mathematics class or with perceived differences in the class itself. One of the major changes from previous mathematics classes was with respect to the way the participants went about working their homework. Elliot really didn't have to work homework in past high school and college math classes and this changed when he started in technical calculus. He states that there has been a change from previous mathematics classes because "all my previous math classes I didn't study at all. I didn't do any of the homework and still could get A's. It just came natural, but here just starting off, I had to do a whole lot more work just to keep up at all" (5: 94 - 96). Rachel agreed with Elliot with "I realized that I can't just not do the homework and not study and get a B or an A [in technical calculus]" (18: 380 – 381). Isaac usually just gave up on homework that he could not figure out and would turn in what he had finished, but this has changed in this class because of the discussion sessions. He states that he had a

> bad habit that I developed in my last calculus class (he had tried to take engineering calculus in a previous semester, but dropped the class). There were times that I could not get the homework and nobody could figure it out, at least the ones that I knew, my fellow classmates. The solutions manual hadn't helped and going back to the section just confused me more. At that point I would usually just hang it up and say oh well I will

just turn in what I got. But because of these discussion sessions I was able to come and work through the problems, work through those and hand in the homework. Get the homework done and get it right (9: 254 – 260).

Lincoln, like Elliot, never did homework, but not because he knew how to do everything by looking at the notes and learning everything from lecture. Lincoln states that "doing the homework, because I have had other classes like my college algebra class never required homework and I would never do it. This is my whole thing about it, I would never do it and then I would come to exam time and I would have a really hard time with the exam. I would realize that I had to do the stuff that he assigned to us, but wouldn't ever grade it" (12: 59 – 63). Patrick emphasizes that the discussion sessions helped reinforce the homework which helped him know what was going on. He comments that "help through the sessions, the reinforcement form it; just being confident in myself in doing the homework and knowing what is going on" (16: 346 – 347). In addition, he comments that in a previous class, "I guess maybe I didn't pay attention in the right way or just wasn't thinking about things in the proper way. But for some reason this semester I have learned a lot more, I have practiced a lot more; you know I am much more confident on what is going to happen on the test" (16: 336 – 330). Timothy states the difference is "practice, practice, and practice. When you go to class, you go home and you study by yourself, and you have a problem then what are you going to do? Sometimes you are stuck and you have no way to go and talk to the professor" (20: 144 – 146). The last comment is from Valerie, a non-participant. She agrees with Elliot and Lincoln that technical calculus requires students to work. She states that

> most math classes, I didn't have to do much in [them]. Like my algebra class was really easy and my trig class was easy. She [the instructor] gave us a lot of bonus points. The instructor for technical didn't give us any bonus points at all. It was like do it right the first time or you aren't going to get a second chance. I spent a little bit more time, [but] I didn't spend a lot of time. I had to work the homework problems to realize how to do it. And other classes I didn't really need to. This is one of those things that if you don't get it at the beginning then you are going to struggle all the way through because towards the beginning you are starting to do derivatives. Algebra and trig are like that a little bit, but you can pick up in the middle of trig and start understanding (21: 203 – 211).

Another change from previous math classes was being able to find resources for help. Participants comment that in previous math classes they could not always find help. Patrick mentioned above that he received help in the discussion sessions. Henry tried to find help in various ways in trigonometry and stated that the tutors at the MLRC usually got the solutions manual out and "open it up and maybe they could work backwards and explain the steps. I didn't have the resources that I have right now and I didn't have this two hour discussion session" (8: 272 – 274). Jeremy adds to this with "for trig there wasn't anything to really help you and the MLRC said they couldn't help you, but in this class you have this [TCLS] and it really helps" (10: 208 – 210). Kendrick believes that uses a learning system like the TCLS and the discussion sessions would be very beneficial for students. He states "I really think a study sessions is a key thing, because I get really frustrated with the fact that some of the classes I have, you really can't get help in. There is no way around it, if you don't understand it, you are not going to" (11: 225 – 228).

Participants commented about several other changes from previous mathematics classes. Patrick reiterated a few of the reasons mentioned above and adds that he studies differently now; "The way I have studied is the difference. The way I have applied the formula, applied what I have learned in class and what I have learned in the help sessions. It has been more educating for me. I have learned a lot more in this semester than I have in any previous semesters in most of my other math classes" (16: 333 – 336). Dalton and Fred comment about the large lecture classes that they had in previous math classes. Dalton remarks, "I did not have that [approachable instructor] in college algebra because there were so many kids and you already … you didn't get that one on one attention. That is probably the biggest change that I can think of, just willing to help students" (4: 118 – 120). Fred agrees with Dalton when he says, "the last math class that I had was a huge lecture, it was about 100 to 150 students. The only option we had to get help was a one hour session a week and it was not nearly enough for the material that we were covering" (6: 90 – 92). Finally, Lincoln comments that he has actually started understanding math because of the TCLS and discussion sessions; "I am actually starting to understand math from up here [in college] now. So it [TCLS and discussion sessions] has really helped a lot because I went to a [high] school that really didn't teach you that much [math], they were kind of lazy about it" (12: 235 – 237). The TCLS and discussion sessions impacted students in a variety of ways which helped students be more confident in their own math abilities and change their attitudes towards mathematics. This resulted in students understanding the material better and feeling more confident that they could solve problems.

Summary

In conclusion, the data has revealed that students had a variety of backgrounds in math when they enrolled in technical calculus, and math anxieties and obstacles to overcome when learning the material. Students used the TCLS and discussions sessions for a variety of reasons and in a variety of ways throughout the semester. The perceived that the TCLS and discussion sessions helped them learn the course material and be more successful in the course. Furthermore, students felt that they benefited from using the TCLS and discussion sessions in many different ways. Although numerous participants used the discussion sessions and TCLS, there were other students that provided various reasons why they choose not to use the TCLS or attend the discussion sessions. Many of these students successfully passed the course, however there were other students that were not successful. We will see in the next section the conclusion for this study.

CHAPTER V

CONCLUSION

The purpose of this study was to describe students' perceptions and perspectives of the TCLS and discussion sessions, students' experiences with the TCLS and discussions sessions, and to describe and compare the improvement in algebra skills over the course of the spring 2005 semester for participants and non-participants. The research questions guiding this study were:

i. What are the experiences of technical calculus students with the Technical Calculus Learning Supplement (TCLS)?
   (a) What components of the TCLS do students use and why do they use those components?
   (b) What components of the TCLS do students not pay particular attention to and why do they not use them?
   (c) How do students use the components of the TCLS? (Are students using it the way we intended it to be used?)

ii. What are the students' perceptions of the TCLS?
   (a) What are the students' perceptions on how the TCLS helps them in the course?
   (b) How much do students attribute their success in the course to the TCLS?
   (c) What is the students' overall opinion of the TCLS?

iii. What are the experiences of technical calculus students with the group sessions?

(a) What are the reasons for students to attend or do not attend the discussion sessions?

(b) Are most of the students that attend the discussion sessions also students who attend the class regularly?

iv. What are the students' perceptions with respect to the group sessions?

(a) To what extent do students contribute their success in the course with the discussion sessions?

(b) What are the students' perceptions of the three step method structure of the discussion sessions?

(c) What is the students' overall opinion of the discussion sessions?

v. How do the course grades and the pre and post-algebra assessment scores for those students who attend the discussion sessions and use the TCLS compare to students who do not attend the discussion sessions?

vi. When do the students use the TCLS?

vii. Are there parts of the TCLS that should be expanded and/or deleted?

viii. Should anything be added to the TCLS so that it better serves the students?

The researcher will address each question as indicated by analysis and interpretation of the collected data. In order to do this in the most efficient way, the researcher will state the research question or sub-question, and then state the analysis and interpretation for that particular question. This chapter will end with a discussion of future research suggestions and with final comments about the research.

What components of the TCLS do students use and why do they use those components?

To answer this question, the researcher analyzed the website counters for each of the components. The data revealed that all components were visited during the semester. The order from the most hits to the least hits during the spring 2005 semester were the LAMS (591), how to study math (133), QAR (118), QTR (115), how to use the TI-83 calculator (75), and applications from engineering technology (58). The quick answer to, what components of the TCLS do students use, would be all components were used. However, a little deeper look shows that some components were used in a more limited role.

Two components that were used in a limited role were the how to use the TI-83 calculator, and applications from engineering technology components. The least visited component was the applications from engineering technology component. This component had one-fourth of its total visits during the first week of the semester. The researcher went to each technical calculus class at the beginning of the semester to tell students that discussion sessions were being offered during the semester. In addition, the researcher wrote the address to the TCLS website down on the board and described the different components on the TCLS to the students. The researcher believes some of the visits to the TCLS website during the first week were students browsing the TCLS website. Which would say some of the visits to the applications from engineering technology during the first week, can be attributed to students initially visiting this component to see what it contained. In addition, there were 83 out of 106 days (83%) where the applications for engineering technology had no visits, and 7 days (6.6%) with only 1 hit. Thus the data shows that almost 90% of the time, the application from engineering technology wasn't being used or was used in a limited fashion. Hence students were not seeing the need to visit the applications from engineering technology to get real life examples of how calculus is used in their majors.

The how to use the TI-83 calculator component was another component that got fewer hits during the spring 2005 semester. Unlike the applications from engineering technology, it can be argued that the how to use the TI-83 calculator component was used during the semester, but with less frequency than the other components. The data shows that 54.3% of the total hits to this component occurred after week 10 and 16.4% of the hits (23 hits) occurred during pre-finals week. The researcher believes that students visited this component later in the semester, because there is more material later in the semester where students use their calculator. For example, near the end of the semester, students learn how to approximate integrals using the trapezoidal rule and Simpsons rule. In addition, students learn how to solve max-min problems, related rate problems, and how to graph functions using principles learned in the course later in the semester. There were 61 days (57.5%), out of 106, where the how to use the TI-83 calculator component was not used at all, 15 days (14.2%) with only 1 hit, 8 days (7.5%) with 2 hits, 18 days (17%) with between 3 and 8 hits, and 3 days (2.8%) with 9 hits. Therefore students did not use the how to use the TI-83 calculator component very much, but when they did use it, they used it near the end of the semester when they had a greater need for the calculator. The counters show that the other components were used more than the applications from engineering technology and how to use the TI-83 calculator components. We will go over when during the semester these components were used when answering research question 6 that asks "when do students use the TCLS."

Now we turn our attention to answering why students used each component on the TCLS. We will not be able to answer this question for all components because students did not go in detail about why they used the QTR component and the applications of engineering technology. Furthermore, students talked very little about how they used the how to use the TI-83 calculator component. The TCLS questionnaire revealed that the reasons why participants used the TCLS were: they wanted to get a higher grade in the class, they heard the TCLS was helpful, they learned the course material better by using the TCLS, the TCLS helped when working assignments, students feared that they might fail the class, and the TCLS helped with understanding the process of solving problems.

Examining the interviews, the researcher found some of the reasons why students used the different components of the TCLS. The reasons why students used the LAMS were: 1) as a guide to working and presenting the homework, 2) to help them study for exams, 3) to get help with homework when the instructor wasn't available, and 4) to construct a help sheet that could be used on exams. The reasons why students used the QAR component were: 1) review algebra and 2) correct mistakes on homework, quizzes, and extra practice problems. The reasons why students used the how to study math component were to get advice on how to study math, and in particular, how to be more successful on the exams. The reasons why students used the how to use the TI-83 calculator component were to review or learn how to use the TI-83 calculator and to see how to graph functions.

What components of the TCLS do students not pay particular attention to and why do they not use them?

The general reasons that participants and non-participants did not using the TCLS were: students did not see the need to use it, students misunderstood exactly what kind of help one could get from it, students forgot about the TCLS after the researcher's initial class visit, students weren't exposed to it very much during discussion sessions, students had algebra and computer issues, students had no time to use the TCLS, and laziness. The reasons for limited use of the TCLS were: the discussion sessions gave better help, students had time to only use just the LAMS, and students weren't aware that the other components were available.

On the TCLS questionnaire, students who did not use the TCLS were asked to answer statements, on a Likert scale from 4 = strongly agree to 0 = strongly disagree, that were phrased "I did not use the TCLS because" with a stated reason. The researcher analyzed the results and drew the conclusion that students were answering the questions with a response from 0 to 4 in response to the reason stated after the statement "I did not use the TCLS because." For example, the sixth question was "I did not use the TCLS because I didn't have access to a computer." The question had an average response of 0.455. That is, the majority of the students either strongly disagreed or disagreed with this statement. The breakdown of the responses, were: 18 students strongly disagreed, 1 student disagreed, 3 students agreed, and 1 student did not answer the question. Therefore, student's choice not to use the TCLS was not because they did not have access to the TCLS. Furthermore, for three students, this was another reason why they did not use the TCLS.

The first statement was “I did not use the TCLS because I didn’t need the help in this class.” The breakdown of responses, were: 8 students strongly disagreed, 4 students disagreed, 4 students neither agreed nor disagreed, 3 students agreed, 3 students strongly agreed, and 1 student did not respond. The average response on this statement was 1.5. This response to this statement is a little harder to analyze, because six students responded that this is the reason why they did not use the TCLS, however, 12 students responded that this is not the reason that they did not use the TCLS, and 4 students were neutral. The response from students that this is a reason that they did not use the TCLS agrees with some of the reasons why students have stated in the interviews on why they did not use the TCLS.

The second statement was “I did not use the TCLS because I could not find the necessary time”. The breakdown of responses, were: 8 students strongly disagreed, 8 students disagreed, 3 students neither agreed nor disagreed, 2 students agreed, 1 student strongly agreed, and 1 student did not respond. The average response on this statement was 1.091. The majority of the responses either disagreed or strongly disagreed with this statement with a few responding neutral, agreeing, or strongly agreeing. Therefore, the nonuse of the TCLS by the majority of the students was not because their schedules were so packed that they couldn’t find the time to use the TCLS. Three students responded that they were too busy to find the time to use the TCLS and that is in agreement with why students did not use the TCLS that was found by interviewing the students.

The third statement was “I did not use the TCLS because it didn’t seem helpful to me.” The breakdown of responses, were: 14 students strongly disagreed, 4 students disagreed, 1 student neither agreed nor disagreed, 1 student agreed, and 3 students did not respond. The average response on this statement was 0.45. Only 1 student felt that they did not use the TCLS because it did not seem helpful to them. The majority of the students either strongly disagreed or disagreed with this statement, which says that this is not the reason why they chose not use the TCLS. Although, one student felt like the TCLS did not seem helpful.

The fourth statement was “I did not use the TCLS because I heard it wasn’t helpful.” The breakdown of the responses, were: 18 students strongly disagreed, 4 students disagreed, and 1 student did not respond. The average response on this statement was 0.182. All students responding to this question either disagreed or strongly disagree with this statement, which says that this is not the reason why students did not use the TCLS.

The fifth statement was “I did not use the TCLS because I didn’t know about it.” The breakdown of the responses, were: 9 students strongly disagreed, 1 student disagreed, 3 students neither agreed nor disagreed, 3 students agreed, 5 students strongly agreed, and 2 students did not respond. The average response on this statement was 1.714. Ten of the responses disagreed or strongly disagreed, which says that this is not the reason why they did not use the TCLS. Eight students agreed or strongly agreed that this is one of the reasons why they did not use the TCLS. This reinforces what some of the participants and one of the non-participants have said that they did not know about the TCLS.

After students responded to the 6 statements, the questionnaire asked them to include other reasons why they did not use the TCLS. Four responses were given, but only one was different than the six statements above. That student wrote that he or she did not use the TCLS because he forgot about it. Thus he or she is acknowledging that they either were present on the day the researcher announced it in class or learned that it was available by another source and then simply forgot about it as the semester went on. Again this reinforces what other students said, during the interviews, were the reasons why they did not use the TCLS.

In summary, the reasons why participants and non-participants did not use the TCLS were: 1) students did not see the need to use it, 2) students misunderstood exactly what kind of help one could get from it, 3) students forgot about the TCLS after the researcher's initial class visit, 4) students weren't exposed to it very much during discussion sessions, 5) students had algebra and computer issues, 6) students had no time to use the TCLS, 6) laziness, 7) students did not need the help, and 8) students felt it was not helpful.

How do students use the components of the TCLS?

To answer this question, the researcher examined the transcribed interviews. In particular, the researcher examined the answers to a question about how participants used the components of the TCLS pertaining to the components that each participant used during the spring 2005 semester. Participants discussed how they used the LAMS, how to study mathematics, the QAR component, how to use the TI-83 calculator, and the applications from engineering technology, however the LAMS was the only component that the participants talked about extensively. The researcher will begin answering the question for the LAMS and then answer the question for the other components.

It has been shown that the LAMS were used by 15 of the 20 participants that interviewed with the researcher and who used the TCLS and attended the discussion sessions. The majority of the participants used the LAMS in the following way: a participant would be working on homework or working problems for practice and would get stuck on a particular problem. At this point the participant would browse examples on the LAMS corresponding to the chapter and section for the given problem. The participant would locate an example on the LAMS that was very similar to the problem that they were having problems with and use the example on the LAMS to help them complete the problem in question or to help them understand the rules of calculus in order to solve the problem. This was not the only way participants used it though. Several participants said that they would work through each step of the problem as they reviewed each step of the similar example from the LAMS and other participants stated that they worked completely through an example or several examples on the LAMS and then returned to the problem that they were stuck on. In addition, other students would not just pull up examples on the LAMS when they were stuck on a problem, they would pull up the LAMS problems for a particular chapter and the detailed solutions of those problems as they worked through the homework referring back and forth from their work to the examples on the LAMS.

Three of the 20 participants used the how to study math component during the spring 2005 semester. They stated that they read the how to study component to get hints on how to perform better on the exam and they did not state that they used the component for any other purpose. Five of the 20 participants used the QAR component. They stated that they used the QAR component to review algebra and correct algebra mistakes. The extent of how they used the QAR component varied from students using it as an algebra reference when they were stuck on a problem, to reviewing periodically different sections of the QAR component to brush up on their algebra background. For example, Rachel and Alex went to the QAR component periodically to go over a specific area that they felt like they did not have a good grasp on. Finally, 1 out of 20 participants used the how to use the TI-83 calculator component and applications from engineering technology. The participant that used each of these components used the how to use the TI-83 calculator component to review how to graph equations and other basic functions. Furthermore, this participant said that they browsed the application from engineering technology component and said that they read through some of the statements of the problems, but did not work out any of the problems.

What are the students' perceptions on how the TCLS helps them in the course?

To answer this question, three things will be considered: students' perceptions on how they would do in the course without the TCLS, students' responses on the TCLS questionnaire, and a summary of comments from the interviews.

Students had a variety of opinions on how they would do in the course if they did not have the TCLS as an instructional tool. The responses varied from comments that I am not sure if I would even pass the class to comments that it would not have had much effect on my grade. For example, Alex stated "I am not sure if I would even pass. I would either fail or get a D" (1: 289 – 290), Stephen stated that "if I didn't use the website for any of this, I would probably be average, maybe a C" (19: 155 – 156), and Timothy commented "it helped, but I really think the sessions are what really helped. So I don't think there would be too much of a change [in my grade]" (20:130 – 131). The students that stated that there would be little effect on their grade are students that used the TCLS in a more limited role or not all, compared to the students that said there would be a big effect in their grade, even to a point that they would not pass the course, if they did not use the TCLS. The five students that stated either they might not pass the class without the TCLS or their grade would be greatly affected in the course ended up with 2 B's, 2 C's, and a D. In their opinion, the TCLS was a great help in making non failing grades in the course. The students that said that the TCLS helped them somewhat in the course stated that if they did not have the TCLS then their grade would drop no more than a letter grade. One student, who was making a B at the time of the interview, stated that he would probably be making a C if he did not use the TCLS. He ended up with an overall grade of B in the class. Another student, who was making an A at the time of the interview, stated that he might have to scramble for an A if he did not use the TCLS and another student stated that he was hoping to pass the class and with the help he received from the TCLS he has a chance of making a B in the class. He ended up in the class with a high C. Therefore sometimes the students' perception of how the TCLS helped them in the course was higher, sometimes lower, and sometimes about the same as the grade they actually earned in the course.

It appears that for some of the students the TCLS helped them perform better in the course and earn a better grade than they would have without the TCLS. But in what ways did students perceive that the TCLS was helping them in the course? To begin to answer this question, the answers that students provided on the TCLS questionnaire will be examined. On a scale of 4 = strongly agree to 0 = strongly disagree, students felt the

TCLS helped them the most on understanding the course content and the TCLS helped them obtain a better grade in the course, by responding with an average response of 3.5 on both statements. Students agreed, with an average response of 3.167, that the TCLS helped them pass the class, and also, with an average response of 2.833, that the TCLS helped them increase their exam scores. Students agreed somewhat that the TCLS helped them improve their study skills for the class.

The interviews added further depth on how the TCLS helped students in the course. Students used the QAR component of the TCLS to 1) refresh or brush up on their algebra knowledge, and 2) correct algebra mistakes. Students used the LAMS a lot more than they used the QAR component and the data shows that the LAMS was used explicitly to: 1) aid when working homework, 2) help study for exams, 3) demonstrate how the homework should be written up, 4) serve as a substitute for the instructor or for the discussion sections by answering questions for a student who is working on his or her own, 5) construct a help sheet with examples from the LAMS that were used for exams, 6) give more examples that were worked out, 7) show step by step solutions for problems that would help students solve other problems, and 8) reinforce concepts from the class. Finally students used the how to study component of the TCLS to help prepare for exams and reviewed the component after exams so that they could do better on the next exam.

How much do students attribute their success in the course to the TCLS?

The answer to this question was partially given while answering the research questions above, however a more complete answer is given by looking at how the TCLS has helped students be more successful on the homework and exams, as well as in the whole course. Students' perceptions on how much the TCLS helped them to be more successful on the homework varied from "it helped very little" to "it helped them dramatically." Many students (Alex, Brett, Jeremy, Neal, Oliver, Patrick, and Rachel) could not pinpoint exactly how much their homework grade was affected by using the TCLS, but they all said that the TCLS helped increase or raise their homework grade. For example, Oliver stated that the TCLS helped raise his homework grade, but he did not stop there, he stated that it helped raise it because "you could see step for step what to do and on your homework you could follow those guidelines which would help you do you homework, which would cause you not to have errors in your assignments and dock you points for your grade" (15: 128 – 131). Brett stated that by using it frequently, the TCLS helped him make better homework scores. In fact, Brett states that he has some of the best homework scores in the class. Unlike Oliver, Brett and other students, Mary and Stephen stated that they did not use the TCLS extensively and the TCLS only helped them on their homework minimally. While Henry and Timothy stated that the TCLS did help increase their homework scores, but increased it less than a letter grade. Therefore, students' perception of how the TCLS helped them on their homework varied from student to student, however, all students perceived that their homework scores improved.

All the students that commented about how the TCLS helped with regard to their exam scores said that the TCLS helped improve their exam scores. Either the TCLS helped them increase their exam scores in a small way resulting in improving their grade from 5 to 30 total points in the course, or helped them improve their exam scores a lot. Alex, Brett, Neal, Oliver, and Rachel were five students that felt like the TCLS helped them improve their exams scores dramatically. In essence, they stated that the since the

TCLS helps them when working homework, helps them understand the concepts, and helps them to be more confident in technical calculus, it results in better performances on the exams.

Students' perception on how the TCLS helped them was better revealed when the researcher looked at the student perceptions on how they would do in the class without the TCLS. One student said without the TCLS he/she would have a B+ or A- in the course and has a solid A in the course with the TCLS, another student said that without the TCLS he/she would have made a B in the course and has either an A or B with the TCLS. Two students said they would have made a C in the course without the TCLS and have either a B- or B with the TCLS. Three students said they would have made D's in the course without the TCLS and all three said that they will make a B with the TCLS. One of the students stated that possibly their grade would have possibly slipped into the C range, and two other students said without the TCLS would have either failed or withdrawn from the course and with the TCLS they will make either a B or a C in the course.

Therefore in the eyes of some of the participants the TCLS helped them be more successful in the course while others believed the TCLS helped them in a more minimal sense. In any case, the students believe that the TCLS has helped them be more successful in the course than they would have been if they had not used it.

What is the students' overall opinion of the TCLS?

Students' overall opinion of the TCLS was very positive and varied depending on how much students used the TCLS. To answer the question of what is the students' overall opinion of the TCLS, the researcher looked at the overall data along with the answers to two specific questions. The two questions on the interview that probed student's overall opinion on the TCLS were: 1) tell me about how the learning supplement as a whole has helped you in the course, and 2) describe to me how the TCLS has contributed to your overall understanding of the concepts in technical calculus. The student's overall opinion of the TCLS was that it was a secondary resource that was available all the time so that students could get extra help and see other problems worked from the book. The TCLS was very beneficial in looking for ideas on how to solve problems, helping to clarify concepts, or helping to contribute to their overall understanding. In addition, several students said that it was very helpful when needing to review algebra or help them find a way to continue working on a problem when they were stuck. Finally, students felt that the TCLS helped them be more confident with the material and it was like having a personal tutor available when students needed help.

What are the reasons for students to attend or do not attend the discussion sessions?

Students attended the discussion sessions for many different reasons, with some of the reasons being very similar. The students revealed that they attended the sessions for the following reasons: to help them obtain better homework and exam scores and a better overall grade, to help them with their homework, to help them grasp the material in the course, to help them clarify the lectures and course material, to help them remember the material, to help them work and understand the homework, to help them set aside time to study, because they made a low exam score and wanted to do better on future exams, to help in keeping up with the course material, or a friend suggested that they attend. The reasons here were varied but most of them came down to improving their grades.

Students did not attend the discussion sessions for a variety of reasons. One of the most common reasons was because students did not need the help. Students did not need help because they stated that they were doing well in the course and could understand the material on their own or they could get the help when they needed it in class or by visiting the instructor during office hours. Students also stated that they did not attend the discussion sessions because they forgot that the discussion sessions were available or that the discussion sessions were offered at times that were inconvenient. Students also stated other reasons why they did not attend the discussion sessions which included: found help at the MLRC, found help from family, was busy with other things, and they didn't want to attend. In addition, students that attended the discussions for a period of time, but stopped coming, stated reasons why they quit coming to the discussion sessions. The reasons stated were: family obligations, conflicting schedule, difficulty taking off from work, and knowledge base was sufficient to proceed in the course after attending the discussions for a review. These reasons aligned, for the most part, with some of the reasons that non attendees gave above. The last group of students that stated reasons for not attending the sessions was two non participants. They did not attend because one of them was doing really well in the class, and the other misunderstood what the discussion sessions were all about. Both of the non-participants stated that if they could do it all over again they would definitely attend the discussion sessions because the sessions really helped in understanding the course material and gave students extra practice with problems in technical calculus.

The comments from some students who did not attend the discussion sessions, especially the two that interviewed with the researcher, revealed that some students do not attend the discussion sessions because they have forgotten about them or they do not understand what the discussion sessions are all about. The researcher could have resolved the problem concerning these two reasons by periodically visiting both sections of technical calculus and advertising when the discussion sessions were available. In doing this, other students' interest levels in the discussion sessions might have increased, resulting in more students attending. In addition, demonstrating with a lesson in class on how the discussion sessions were structured might also convince other students that they might benefit from attending the discussion sessions and working in groups with other students.

Are most of the students that attend the discussion sessions also students who attend the class regularly?

This question gives a measure of the motivation of students that attended the discussion sessions in attending class and learning the material. In addition, the researcher will compare the attendance of the students that did not attend the discussion sessions with those who did. The researcher did not include any student who had withdrawn from the course or any student who was making a failing grade and appeared to quit coming to class even though they did not drop.

The researcher obtained the attendance record for each class from both instructors of technical calculus. One instructor took attendance regularly throughout the semester and the other instructor took attendance regularly from week 1 through week 13 of the class. The reason why the instructor that only took attendance through week 13, stopped taking attendance, was because only between 15 and 25 students were attending the class near the end of the semester.

Students who attended the discussion sessions during the spring 2005 semester missed from 0 to 9 days of class out of a total of 48 days of class. These results do not include students that quit attending the discussion sessions at some point during the semester. However, it does include the participants that stopped attending the discussion sessions for a period of time, but started coming to the discussion sessions again before the semester was over. The breakdown of days missed for the 18 students that interviewed with the researcher and attended the sessions during the spring 2005 semester were: 1 student missed 0 days, 3 students missed 1 day, 5 students missed 2 days, 3 students missed 3 days, 2 students missed 6 days, 2 students missed 8 days, and 2 students missed 9 days. These 18 students missed on average 4.0 days, with a standard deviation of 3.09, during the spring 2005 semester. In contrast, non participants missed between 0 and 27 days during the spring 2005 semester with an average of 7.44 days missed per student with a standard deviation of 8.22. The researcher determined using a one tailed t-test that participants missed significantly less days in class than non-participants. Therefore, participants did not use the discussion sessions as a substitute for the regular class meetings and attended significantly more of the regular lectures than non-participants.

To what extent do students contribute their success in the course with the discussion sessions?

Students have a variety of opinions of how the discussion sessions helped them be more successful in technical calculus. First students commented that the discussion sessions helped them be more successful on the homework and exams. All participants commented that the discussion sessions helped them earn a better grade in the course and this resulted from them being more successful on the homework, however, there was a variety of comments on how much students believed that the discussions sessions helped with homework and exam scores. The discussion sessions helped students be more successful on the homework in a number of ways, including but not limited to, 1) it helped students to better understand the topics of the course by working problems in a repetitious format during the sessions, 2) it cleared up confusion that resulted from the lectures and clarified the concepts in the course, 3) it helped students to complete their homework on a certain topic, 4) it helped focus the students and keep them up to date on the material, and 5) it helped students to reinforce and retain the course material.

A consequence of the discussion sessions helping students be more successful on the homework is that this sometimes helped them be more successful on the exams. By working problems out during the discussion sessions and outside of discussion sessions, students became more comfortable with the material and more confident in their ability to solve technical calculus problems. In turn, students would be more successful on exams and in the class. Students also stated that they were more successful on exams because the discussion sessions helped prepare them for the exam. This occurred not only because students reviewed for an exam during the session, but also occurred because, as stated earlier, they were familiar with the material which resulted from working many problems in and out of the discussion sessions.

What are the students' perceptions of the three-step method structure of the discussion sessions?

Now we look at the question about the students' perceptions of the three-step method. Students don't always remember what has been said in lecture. The students sit passively watching the instructor lecture on a particular section of technical calculus. It seems easy at the time, students follow the lecture and say that it is clear, but when they get home and try to work the homework, they sometimes have a hard time remembering how to work the problems. Elliot states "as far as class, the instructor would present the material but he does it himself on the board. Most of the time it made logical sense how to do it, but you go home and you have your own problems and it is just like how did he do that." The three-step method encourages students to be active in the learning process so that they can understand the material. According to William, the three step method puts the responsibility on the students "instead of [the instructor] spoon feeding it by saying this is how you do it. [The instructor] was alright, look at this [problem]; how do you think it is going to be done." (22: 392 – 393) By having students review a problem with the instructor, help the instructor work a problem, and then work a few problems by themselves, students felt more comfortable with the material of technical calculus and understood the material better. The three-step method allowed students to actively engaging themselves in the problem solving process in an environment that they felt was conducive to them learning the material. They were not worried about being wrong, but they concentrated on understanding the material. Students could make their own assessment on whether they understood the material or not, when the three-step method was being used, because they were the ones checking their own work. Never did the researcher ask ‘who got the right answer’ to see how many understood the material. This was a safe environment where students did not worry if someone was assessing them and created a learning community where everybody was important. Oliver said it best when he said the three-step method “ is the key, you get to see how to do a step, work through it together, and then give you a single problem that you can do on your own. It just becomes more natural”(15: 180 – 183). So students believed that the three-step method was instrumental in getting students actively involved with the material, and enabled them to better understand the concepts of technical calculus.

What is the students’ overall opinion of the discussion sessions?

The student’s overall opinions of the discussions varied, however all of the comments that students made about the discussion sessions were positive. The discussion sessions were a place where students could meet together, talk about the material with each other and the researcher, and work together to understand the material. The culture of the discussion sessions was one where students felt comfortable talking about mathematics and did not have any reservations about supplying answers even though they might be wrong. During a discussion session, it wasn’t uncommon to find students working on different material than was being covered in the discussion sessions, or working with other students occasionally or participating with everybody else in understanding the material being covered in the discussion session. This type of culture encouraged students to participate and did not make them feel awkward if they didn’t understand the material. In a discussion session, it was normal for students to have a level of understanding that encompassed the whole spectrum from not understanding to completely understanding the material.

One common overall opinion from students about the discussion sessions was that the discussion sessions helped them pass the course or helped them make better grades than they would have if the sessions were not available. The structure of the discussion sessions allowed lower level students, or at least students that felt that they were at a lower level, to go from not understanding the material to where they felt confident enough to work problems on their own. The discussion sessions resulted in changing students' expectation from saying they would "fail the course," to saying that "this actually helped me pass this class", and students saying they would earn a high grade to students who said the discussion sessions helped them to "be more successful in the course."

The researcher asked students what was the most helpful aspect with regards to the discussion sessions and their overall opinion about the discussion sessions, and their overwhelming opinion was centered around seeing problems worked through the three-step method and getting more actively involved by working problems. Their statements varied somewhat, however, they always dealt with the three-step method and working problems by themselves in order to understand the topics. Two examples of answers to this question are from Oliver and Rachel. Oliver states that "you get to see someone work out problems and then you get to go and try examples [other problems]. Then if you can't still figure out the examples then someone is there to help you work you way through it. It is a great way to learn, just by seeing it and then by trying it yourself" (15: 237 – 240).

Rachel comments that “I like to see one [problem] and well I kind of got it. Then when we talk the researcher through another one, you hear it from other students, and for some reason it clicks in your mind. And then doing it on your own, for a while there I called my dad and said wow, I can do this calculus, so when I can do one after you said do one on your own and I got it right I was like wow. It was a good feeling; I didn’t think I could even pass this class” (18: 418 – 423). Some students commented that certain steps of the three-step method were the most important aspect of the discussion sessions with either seeing examples worked or working examples by themselves as the most important steps. Several other overall opinions came out during the interviews. One comment that came up several times during interviews was that students thought the discussion sessions were very helpful because they could interact with other students and also get questions answered that either arose while doing problems on their own or questions that came up during the sessions. Furthermore, the three-step method helps students remember how to solve technical calculus problems on their own, along with helping students realize what their weaknesses were so that they could work on them.

How do the course grades and the pre and post-algebra assessment scores for those students who attend the discussion sessions and use the TCLS compare to students who do not attend the discussion sessions?

The researcher compared the participant’s to non-participant’s final grade in the course in order to investigate if the mean course grade for the participants is significantly different than the mean course grade for the non-participants. The researcher quantified the grades (A = 4.0, B = 3.0, C = 2.0, D = 1.0, and F = 0; withdraws were not quantified) for all 19 participants and 58 non-participants. The researcher determined that the grades of the participants were normally distributed drawing a normal probability plot. The researcher tested if the mean course grade for the participants (2.47), with standard deviation of 0.77, was equal to the mean course grade for the non-participants (2.07), with a standard deviation of 1.42, by using a two sample right tailed t-test assuming unequal variances found in (Larsen, Marx, 2001, p.496). The t-statistic came out to be 1.57 with 57 degrees of freedom and the p-value of 0.0610. We find that the mean course grade for the participants is significantly different than the mean course grade of the non-participants ($\alpha = 0.1$). Therefore, participants earned a higher mean course grade than non-participants.

To examine the pre and post-algebra assessment scores for participants, the researcher computed the gain from the pre-algebra assessment score to the post-algebra assessment score for 17 participants and 32 non-participants who took both the pre and post-algebra assessment. The researcher determined that the distribution for the participant gain from the pre to post-algebra assessment, and the distribution for the gain for non-participants from the pre to post algebra assessment were both normally distributed by examining separately a normal probability plot for each one. The researcher determined that there were no significant difference between the gain in pre to post-algebra assessment scores for participant and non-participant by using a two sample right tailed t-test assuming unequal variance found in (Larsen, Marx, 2001, p. 496). The computed t statistic was -0.1448 with 32 degrees of freedom and a p-value of 0.5703. Furthermore, the researcher determined that there was no significant difference in the mean pre-test scores for the participants and non-participants by using a two sample twosided t-test assuming unequal variances found in (Larsen, Marx, 2001, p.496). Therefore the participants and non-participants started with similar mean pre-algebra assessment scores, and although the participants used the TCLS and discussion sessions, they did not improve their algebra skills significantly more than non-participants during the spring 2005 semester.

In conclusion, participants earned a significantly higher mean course grade than non-participants, however participant's improvement from the pre-algebra assessment to the post-algebra assessment were not significantly greater than non-participant's improvement. Both participants and non-participants improved on average from the pre-algebra assessment to the post-algebra assessment, but improved on average about the same. In fact, participants improved from an average of 9.79 on the pre-algebra assessment to an average of 11.80 on the post-algebra assessment and non-participants improved from an average of 9.69 on the pre-algebra assessment to an average of 11.30 on the post-algebra assessment.

When do the students use the TCLS?

To answer the question, when and where do the students use the TCLS, we will look at the website counters for each component. The researcher recorded the number of hits from the website counter for each component in an Excel worksheet for each day of the semester. The researcher included tables, in the data chapter, for each component that presented the number of hits per week for that component and recorded data for each component on the number of hits that each component received each day for 106 days between January 18, 2005 and May 7, 2005. In order to stay with the way the data was presented in chapter 4, the researcher will answer the question with respect to each component in ranking order from most to least use during the spring 2005 semester.

The LAMS, Learning Assessment Measures, component was used the most of any component on the TCLS during the spring 2005 semester. This component received over 400 visits more than any other component on the TCLS. In addition, 15 out of 20 participants used the LAMS component during the spring 2005 semester. This component was visited the most on February 1, 2005 with 49 visits that day and the next four most visits to the LAMS website occurred during the month of January and February with approximately an average of 31 visits on each day. Over half (54.3%) of the total visits occurred in the first six weeks of class and over three-fourths (78.8%) of the total visits occurred before the thirteenth week of class. In contrast, if we look at five week spans, with the week of spring break not counting as a week, we will see more use of the LAMS occurred during the first five weeks than during weeks 6 through 11, and 12 through 16. Approximately 46.9% of all visits occurred in the first five weeks, 23.2% of all visits occurred in weeks 6 through 11, and 29.2% of all visits occurred in weeks 12 through 16. Also there were only 43 days that the LAMS had no visits at all, and 4 days with only one visit. In contrast there were 38 days with between 2 and 10 visits and 21 days with more than 10 visits. Furthermore, if we look 4 days prior and 4 days after each exam we will find that the LAMS was visited less than one-quarter of the time 4 days prior to and 4 days after each of the exams. For section 1, 20.6% of all visits occurred 4 days prior and 4 days after each of the exams with 7.3% of this occurring 4 days prior to the final (no hits occurred 4 days after the final for section 1). For section 2, 22.7% of all visits occurred 4 days prior and 4 days after each of the exams with 9.5% of this occurring 4 days prior and 2 days after the final. The researcher would conclude that the LAMS were used more extensively to help with homework than preparing for exams near exam dates. Of course the LAMS helped with the homework for the course, which in turn helped students prepare for exams. The LAMS were used more in the first part of the course than later in the course.

The how to study math component was the second most used component on the TCLS, however, it was not used by students uniformly throughout the semester. There were no hits on 83 days (78.3%) of the semester and only 1 hit on 5 days (4.7%). Over one-quarter of the total number of hits occurred during the first week and the researcher attributes at least some of the hits with students browsing the website to see what the TCLS was all about. In addition, almost half of the total number of hits occurred 4 days prior and 4 days after each exam and the final. In particular, section 1 received 57 hits (43%) and section 2 received 64 hits (48 %), out of a total of hits, 4 days prior and 4 days after each exam and the final. The majority of the time that the how to study math component was used, was at the beginning of the semester and 4 days prior, and 4 days after each exam in the class. This indicates that this component was used at times when the students were highly motivated to study calculus. In addition, the locations where students used the how to study component was at work, at the school library or other computer labs on campus, and at home.

The QAR, Quick Algebra Review, component was the third most used component on the TCLS during the spring 2005 semester according to the website counters. In addition, interviews revealed that 5 out of 20 participants said that they used the QAR component during the semester. The QAR component was visited the most on the first day of class after the researcher announced that students could get help with algebra review from the TCLS. By the fifth week of class the QAR component had been visited over half (57.5%) the total visits and over three-fourths (76.4%) the total visits by the ninth week. After the tenth week of class students only visited the QAR component 17 times. The use of the QAR earlier in the semester could be attributed to more students needing a review of algebra earlier in the semester rather than later. Furthermore, the algebra assessment summary sheet that was handed back after students took the algebra assessment, described areas that students needed to work on and possibly was a catalyst for getting students to review some of their weaker algebra areas. Therefore the QAR component was used more extensively at the beginning of the semester than later in the semester.

The QTR, Quick Trigonometry Review, component was the last component on the TCLS and was used the fourth most of any of the components. In addition, 1 out of 20 participants used the QTR components during the spring 2005 semester. Students in technical calculus II could possibly using the QTR component since technical calculus II deals with transcendental functions. Also students that had worked with the researcher in a pilot study during the fall 2004 semester could have used the QTR component since they had knowledge that it was on the TCLS. The QTR component was visited the most on the first day of class and 3 of the 4 next most visited days occurred in the month of January and February. Almost half the visits (47.2%) occurred during the first three weeks and over three-fourths of all visits (80.3%) occurred before the ninth week. Furthermore, 75 out of 106 days (71.4% of the time) there were no visits and 9 days

(8.6% of the time) with only 1 visit. Therefore the QTR was used more during the first half of the course and was visited only 30 days during the semester.

The how to use the TI-83 calculator component was the second to the least used component on the website during the spring 2005 semester. In addition, interviews revealed that 3 out of 20 participants used the how to use the TI-83 calculator component during the spring 2005 semester. The how to use the TI-83 component was visited the most on January 21, 2005, March 29, 2005, and May 2, 2005 with 9 visits each day. The last two days, March 29, 2005 and May 2, 2005, were during pre-finals week and finals week. Over half (51.4%) of the total visits occurred after the tenth week of class and a little under half (48.6%) of the total visits occurred before the ninth week of class. The ninth week of class was spring break and no visits to any of the components occurred during this week. Although the how to use the TI-83 calculator was used throughout the semester regularly, it was used more after the ninth week of class. This is probably because there are more word problems and application of technical calculus problems covered later in the semester.

The applications from engineering technology component were the least used component on the TCLS during the spring 2005 semester. In addition, interviews revealed that 1 out of 20 participants used the applications from engineering technology during the spring 2005 semester. This component was not used very much during the semester because 88 days out of 106 days (83.0%) there were no visits to this component and 7 days with only 1 visit each of those days. So 95 out of 106 days, the applications from engineering technology component were used in a limited role. Furthermore, over half (52.6%) of the total visits to the website occurred in the first three weeks of the semester with 22.8% occurring during the first week. Therefore the applications from engineering technology component were not used much by students during the spring 2005 semester.

Are there parts of the TCLS that should be expanded and/or deleted?

The counters and interviews with students have shown that students have visited and used all the components of the TCLS, however, some components have been utilized more than other components during the spring 2005 semester. For example, the applications from engineering technology component was visited by students, however, students did not visit it very much during the semester and they utilized it in a limited role. The applications from engineering technology were included on the TCLS to show students applications from their particular major. The limited use of this component might suggest that the applications from engineering technology component should be excluded from the TCLS. But it does serve a role, to interested students, on how calculus is used and at least gives them problems from their particular major.

Like the applications from engineering technology, the how to use the TI-83 calculator hasn't been utilized as much as other components. The researcher has argued that although the how to use the TI-83 calculator component hasn't been visited very frequently during the semester, it has been utilized by students at different times at the end of the semester to help with estimating integrals and with application and word problems. This component just presented how to use different algebra and calculus programs on the TI-83 calculator and did not actually give the students the programs themselves. So either adding a way for students to download the programs, directing them to where they can get them, or presenting the programs so that students could program their own calculators, might be added features that might help students and allow calculators to be used in a greater role in the class.

Another feature that could be added to the TCLS is review sheets for exams, and a few students asked for these. This might be done by either giving review problems over each chapter like the book does, chapter tests at the end of each chapter, or giving review sheets over the material that usually shows up on each exam. The students would have to be flexible with the reviews if their instructor gave tests that covered different material than what was on a particular review sheet.

The researcher does not see the need to delete any components on the TCLS since they were all used at different times during the course of the semester by students.

Should anything be added to the TCLS so that it better serves the students?

One thing that the researcher has talked about in the previous research question that might better serve the students, is adding review sheets for each chapter or exams. Several other things might better serve the students if they were added to the TCLS website. For example, the researcher found that the algebra assessment was a tool that some students felt was beneficial. A few interviews revealed that the algebra assessment was one thing that got them to realize that they need to look at the QAR. Not all students felt that they needed to review material on algebra, but some participants believed that reviewing the algebra was an instrumental part of their success in technical calculus. For example, Alex reviewed the QAR a lot in the first month or two of the class and stated that the QAR was the most helpful component because it helped him review his algebra and a good foundation of algebra helped him with the remaining material in the course. So adding the algebra assessment as a multiple choice format assessment on the website might be very valuable asset. The researcher could program the website so that once the student submits the algebra assessment, then the results would be available to the student and recommendations on the student's weaker areas could be made. Thus students could choose to go to the QAR component and review weak algebra areas and/or other resources could be recommended.

Another thing that might be very beneficial for student is working on the TCLS to make it more interactive. In particular, by making the LAMS component more interactive, it could be used so that it might replace the physical discussion sessions and move the discussion sessions to a place where they could become an interactive virtual discussion sessions. That way the students could get help with technical calculus on the TCLS at any time during the year and the help that they could get from the LAMS would be very similar to the help they could get in the discussion sessions. The researcher would have to use some sort of programming so that he the LAMS would present an example, then prompt the students to interact with the computer while a problem is being done, and then give the students a problem or two to do on their own. After sufficient time has passed for students to finish solving a problem, the program would present the problem and ask the student to check their answers and figure out where they made a mistake if they did.

Suggestions for Future Research

During the data analysis phase of this research study, the researcher gave thought about future research related to this study. Suggestions for future research based on findings from this study are:

1. Students in this study had very favorable opinions of the discussion sessions and the three step method. Some non-participants said that they had time conflicts that kept them from attending the discussion sessions. One idea for a learning supplement that could be more useful to all students is one that is both available all the time and one that would simulate the type of help students received in the discussion sessions using the three step method. The researcher is interested in building a learning system that offers an interactive LAMS component. The interactive LAMS component would show them worked problems possibly by video through the computer, let them work with a virtual discussion leader to work on a similar problem, and then work some problems themselves and check their solutions. The study would look at how such a system is helping students be successful in the course and what their perceptions are of such a system.
2. The opinion of the participants in the study about the three-step method was that they thought the three-step method was a key in helping them understanding material that was not clear to them when it was covered in lecture. Through the three-step method students reviewed a problem with the researcher so that they recalled the material that was covered in lecture, they helped the researcher solve another problem by participating in the problem solving process, and final the participants solved a problem or two by working by themselves or in small

groups. That is, they were watching a problem being worked, participating as a group in solving another problem, and independently working on other problems. Does the three-step method help students in learning mathematics better? Since the three-step method is used in the discussion sessions for technical calculus, either a research study would have to be done so that a treatment discussion group would use the three-step method extensively and another discussion group would use normal discussion sessions procedures, or the two different sections of the same mathematics course would be arranged so that the three-step method was used as a technique to discuss problems in one class versus normal classroom techniques used in the other class. The researcher would use both qualitative and quantitative methods to compare the two groups.

3. In students' opinions, the three-step method helped them to actively engage in learning the material in technical calculus. In addition, students had a more positive attitude towards mathematics and more confidence that they understood the material. In a larger study, the researcher would examine in more detail, how the three-step method helps them be more actively engaged in their own learning and compare performance in the class, attitudes towards mathematics, and confidence in problem solving abilities of participants with non-participants.
4. One result of Supplemental Instruction research that this study did not consider was that participants in SI reenroll in college at a higher rate. Using the methods of this study on a larger scale and following the students through the next few years could answer this question.

Final Comments

In the literature review, the researcher reviewed the results of supplemental instruction and cooperative group learning research. The results of this study have reinforced some relevant information. In particular, participants earned higher mean course grades in the class than non-participants and participants had a lower level of D, F, or course withdrawals. However, this study did not last long enough to verify if participants reenrolled in college at a higher rate than non-participants. In addition, some of the research studies on cooperative learning showed that there was a significant difference between the experimental group that used a cooperative group structure in the class or discussion sessions and the control group that used traditional lecture method or traditional discussion session methods. Although we can not say that the group structure was the reason for the significant difference in mean course grades between the participants and non-participants, the group structure did contribute in producing the some of the results. Another relevant point: this study did not just stop with results of past quantitative supplemental instruction research, but examined the perspectives of participants with the TCLS and discussion sessions. In the student's viewpoint the TCLS and discussion sessions helped them to be more successful in the course. We have found that this varied from helping minimally with some students to student's statements that it helped them pass the class or not withdraw from class. In addition, we have seen that students used the components of the TCLS in many different ways in assisting them with the material in technical calculus. Furthermore, the students' viewpoint of the three-step method that was used in the discussion sessions, were that it helped them to review the material covered in lecture; helped them to understand the material better by working through a problem with the discussion leader; and then actively engaging them in their own learning by working a problem or problems individually or in small groups. The students believed that this was the key for them in understanding the material. As a result, many of the students - if not all - had a more positive attitude towards mathematics and felt more confident that they could learn and understand calculus.

The results of this study show that instructional tools developed to assist students in learning the material in a course can in fact help students: 1) to be more successful in the course, 2) to have a more positive attitude towards mathematics, and 3) to feel more confident in themselves to learn and understand math. In conclusion it is the researcher's hope that other instructional tools can be developed that will help students to learn mathematics in a variety of different courses and that research can be done on exactly how these tools can help students.

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APPENDICES

APPENDIX A

ALGEBRA ASSESSMENT AND SUMMARY SHEET

Algebra Assessment for Math 2123

The following is an assessment to measure your understanding of algebra. Circle the correct response for 1 – 20.

1. Determine which of the following is a solution of the equation $2x - 4 = 4(x - 2)$.
   - a) $x = -2$
   - b) $x = -6$
   - c) $x = -1$
   - d) $x = 2$
   - e) none of the above

2. $\left(\frac{2x^{-2}y^{0}}{z^{-3}}\right) =$
   - a) $\frac{2x^2}{z^3}$
   - b) $\frac{2z^3}{x^2}$
   - c) $\frac{2y}{x^2z^3}$
   - d) $2z^3x^2$
   - e) none of the above

3. $(2x+1)^2 =$
   - a) $4x^2 + 1$
   - b) $2x^2 + 1$
   - c) $4x^2 + 4x + 1$
   - d) $4x^2 + 2x + 1$
   - e) none of the above

4. $(4x - 3) + (1 - 2x) =$
   - a) $2x - 2$
   - b) $6x - 2$
   - c) $2x + 2$
   - d) $3x - 5$
   - e) none of the above

5. $\sqrt{2}\left(2\sqrt{12} - \sqrt{27}\right) =$
   - a) $\sqrt{42}$
   - b) -6
   - c) $\sqrt{-6}$

d) $\sqrt{6}$

e) none of the above

6. $3x^2 - 4 + 2x - (3 + x^2) =$

a) $4x^2 + 2x - 7$

b) $2x^2 + 2x - 7$

c) $2x^2 + 2x - 1$

d) $4x^2 + 2x - 1$

e) none of the above.

7. Solve $\frac{2x+3}{5} - \frac{1+x}{2} = \frac{3x-5}{10}$ for x. The solution is

a) $x = \frac{3}{2}$.

b) $x = -3$.

c) $x = -\frac{3}{2}$.

d) $x = -1$

e) none of the above.

8. The solutions to $2x^2 = 6x$ are

a) x = 3 is the only solution.

b) $x = \sqrt{3}$ and x = 0.

c) x = 3 and x = 0.

d) x = 0 is the only solution.

e) none of the above

9. A factor of $x^2 - 9x - 52$ is

a) $(x - 4)$

b) $(x + 4)$

c) $(x + 2)$

d) not factorable

e) none of the above

10. The least common denominator for the fractions $\frac{1}{4x}, \frac{3}{2x^2}$, and $-\frac{5}{2x}$ is

a) $8x^3$

b) $4x^2$

c) $8x^2$

d) 8

e) none of the above.

11. Write $\frac{2x-6}{x^2-9} \cdot \frac{3(x+3)}{2(x-3)}$ in lowest terms.

a) $\frac{3(x+3)}{x^2-9}$

b) $\frac{3}{(x-3)}$

c) $\frac{3}{(x+3)}$

d) $\frac{(2x-6)(3)}{(x-3)}$

e) none of the above .

12. Solving $ax - c = b(x-1)$ for x, you get

a) b

b) $x = \frac{a}{b}x - \frac{c}{b} + 1$

c) $x = \frac{b-c}{a-b}$

d) $x = \frac{c-1}{a-b}$

e) none of the above.

13. The factors of $x^2 - 8x - 7$ are

a) $(x-7)(x-1)$

b) $(x-7)(x+1)$

c) $(x+7)(x-1)$

d) not factorable

e) none of the above.

14. $1 - \frac{2}{3(x+1)} + \frac{3}{2x} =$

a) $\frac{6x^2+11x+9}{6x(x+1)}$

b) $\frac{3x^2+4x+3}{3x(x+1)}$

c) $\frac{6x^2+11x+1}{6x(x+1)}$

d) $\frac{2}{5x+3}$

e) none of the above.

15. Given $f(x) = x^2 - 2x$, $f(-2) =$

a) 8

b) 0

c) 2

d) 4

e) none of the above.

16. Write $\dfrac{x^2+4}{(x+2)} \div \dfrac{2x-4}{x^2+2x}$ in lowest terms

a) $\dfrac{x(x+2)}{2}$

b) $\dfrac{x(x^2+4)}{2(x-2)}$

c) $\dfrac{2(x-2)^2}{x(x+2)}$

d) $\dfrac{4(x-2)}{x(x+2)}$

e) none of the above.

17. The sum of the solutions of $3x^2 - x - 2 = 0$ is

a) $\dfrac{1}{3}$

b) $\dfrac{5}{3}$

c) $-\dfrac{1}{3}$

d) 3

e) none of the above.

18. Evaluating the expression $\dfrac{x+2}{x^2-x}$ at $x = -3$ yields

a) $-\dfrac{1}{6}$

b) $\dfrac{1}{12}$

c) $-\dfrac{1}{12}$

d) $\dfrac{1}{6}$

e) none of the above .

19. $x^2 \cdot x^{-\frac{1}{2}} =$

a) x^{-1}

b) $x^{\frac{5}{2}}$

c) x^0

d) $x^{\frac{3}{2}}$
e) none of the above.

20. $(9x^2y^{-2})^{\frac{1}{2}} =$
a) $\dfrac{3x}{y}$
b) $3x^{\frac{5}{2}}y^{-\frac{3}{2}}$
c) $\dfrac{9x}{2y}$
d) $\dfrac{9}{2}x^{\frac{5}{2}}x^{-\frac{3}{2}}$
e) none of the above.

Summary Sheet
Algebra Assessment Test
Math 2123
January 10, 2005

Name:

Score on Assessment Test: _____ out of 20.

Breakdown of performance:

Topic in Algebra	*# of correct responses*	*Total # of questions*	*% correct*
Basic Algebra Skills		3	
Solving linear equations		3	
Solving quadratic equations		2	
Factoring algebraic expressions		2	
Working with Algebraic fractions		4	
Working with exponents		4	
Evaluating expressions		2	

Recommendations for success in class:

APPENDIX B

TCLS QUESTIONNAIRE FOR PARTICIPANTS AND NON-PARTICIPANTS

TCLS FOR STUDENTS WHO **<u>HAVE USED</u>** THE TCLS

Directions: Fill out this side if you **<u>have used</u>** the TCLS**.** Fill out the other side if you haven't. Your responses are confidential and **will not influence your grade**.

Using the scale below to rank your responses, please jot down the number that most accurately represents your opinion on statements 1-5 and answer the other questions.

Scale: 4	3	2	1	0
Strongly Disagree				Strongly Agree

1. Using the TCLS has helped me increase my exam scores.______
2. Using the TCLS helped me understand the course content. _____
3. Using the TCLS has helped me improve my study skills for this class. _____
4. I have used the TCLS outside of the regular discussion sessions. _____
5. Using the TCLS helped me obtain a better grade in the course. _____
6. Circle which grade you expected to earn in this class at the beginning of the semester. A B C D F
7. Taking into account your grades in the class up to this point, circle the grade you expect to earn at the end of semester. . A B C D F
8. Check the reasons why you used the TCLS.

_____ Get a higher grade in the class

_____ I heard it was helpful

_____ Learn the course material better

_____ It helped when working assignments

_____ I could get help when my teacher or tutor were not available

_____ Other (please describe)

9. If you used the TCLS and stopped, please tell me why you stopped?

____ Didn't need the help anymore

____ I did not have the time

____ Family Situations

____ It didn't help me

____ Other (Please describe)

10. How many times did you use the TCLS?
11. Announcing that the TCLS is available on the web and how the TCLS can help you for this class has not caused some students to use the TCLS. If you were in charge of the TCLS system, what would you tell students to get them to use the TCLS?

TCLS SURVEY FOR STUDENTS WHO **HAVE NOT** USED THE TCLS

Directions: Fill out this side if you **have not** used the TCLS. Fill out the other side if you have. Your responses are confidential and **will not influence your grade**.

Using the scale below to rank your responses, please jot down the number that most accurately represents your opinion on statements 1-5 and answer the other questions.

Scale: 4	3	2	1	0
Strongly Disagree				Strongly Agree

1. I did not use the TCLS because I did not need the help in this class. ____
2. I did not use the TCLS because I could not find the necessary time. ____
3. I did not use the TCLS because it did not seem helpful to me. ____
4. I did not use the TCLS because I heard it was not helpful. ____
5. I did not use the TCLS because I did not know about it. ____
6. I did not use the TCLS because I did not have access to a computer. ____
7. Please include any other reason(s) not mentioned above why you have not used the TCLS.

8. Circle which grade you expected to earn in this class at the beginning of the semester. A B C D F

9. Taking into account your grades in the class up to this point, circle the grade you expect to earn at the end of semester. . A B C D F

10. Announcing that the TCLS is available on the web and how the TCLS can help you for this class has not caused some students to use the TCLS. If you were in charge of the TCLS system, what would you tell students to get them to try the TCLS?

Note: *Contact David Miller if you are interested in getting help in studying for your final in Technical Calculus. Limited Spots available and by contacting David Miller you are saying that you are willing to participate in a scheduled 30 minute to 1 hour interview with David which will be conducted by the end of Pre-finals week.*

APPENDIX C

DISCUSSION SESSION QUESTIONNAIRES

Discussion Session Questionnaire

_____Signed up at the beginning of the semester for the discussion sessions

____ Attended the discussion sessions during the semester

1. Describe in detail how and to what extent the sessions contributed to your study of technical calculus this semester?

2. Describe some ways that the discussion sessions could be improved.

3. Check the following courses below that you have taken in high school.

___ Pre-algebra	___ Pre-calculus
___ Algebra I	___ Calculus
___ Geometry	___ Business Math
___ Algebra II	___ Statistics
__ Trigonometry	___ Other (please list other courses below)

4. What grade would you expect in Math 2123 if the sessions were not offered and why?

Discussion Session Questionnaire

_____Signed up at the beginning of the semester for the discussion sessions

____ Attended the discussion sessions during the semester

____ Stopped attending the discussion sessions at some point during the semester

1. Discussion sessions were offered this semester to assist students in learning the material in technical calculus. In addition, you should interest at the beginning of the semester by signing up for the discussion sessions. Describe some of your reasons for showing initial interest in the discussion sessions, attending some of the sessions, but quit coming at some point during the semester to the discussion sessions.

2. Describe the necessary circumstances that would need to be in place, so that you would attend the discussion sessions.

3. Check the following courses below that you have taken in high school.

___ Pre-algebra	___ Pre-calculus
___ Algebra I	___ Calculus
___ Geometry	___ Business Math
___ Algebra II	___ Statistics
__ Trigonometry	___ Other (please list other courses below)

Discussion Session Questionnaire

____Signed up at the beginning of the semester for the discussion sessions

____ Attended the discussion sessions during the semester

____ Stopped attending the discussion sessions at some point during the semester

____ Never attended the discussion sessions

1. Discussion sessions were offered this semester to assist students in learning the material in technical calculus. Describe in detail the different reasons you had in not attending any of the discussion sessions.

2. Describe the necessary circumstances that would need to be in place, so that you would attend the discussion sessions.

3. Check the following courses below that you have taken in high school.

___ Pre-algebra	___ Pre-calculus
___ Algebra I	___ Calculus
___ Geometry	___ Business Math
___ Algebra II	___ Statistics
__ Trigonometry	___ Other (please list other courses below)

APPENDIX D

INTERVIEW QUESTIONS

Interview Questions for Pre-Study
Fall 2004
Math 2123

I will first start out the interview with the interviewee with more general questions about the course. This will allow the students to bring up the online learning supplement and/or discussion sessions on their own. After asking questions 1-10, the student will either talk about the online learning supplement or discussion sessions or not. If they mention either one then the interview will continue with questions 11 through 26 and 33 through 40, if they do not mention either one then the interview will proceed with questions 27 through 32.

1) Tell me about your experiences in technical calculus class this spring.

2) Tell me how you went about working the homework for this class.

3) Tell me how you went about preparing for the exams for this class.

4) When talking to other students in technical calculus they bring up that they make algebra mistakes frequently and we discuss ways to improve their algebra skills so that they won't make as many mistakes in the future. Tell me how you go about working to correct your algebra mistakes.

5) Tell me about your experiences using a calculator for this course.

6) Tell me about the resources that you used during the course of this semester.

7) What aspect in the course was helpful to you?

8) Tell me about how this aspect was helpful to you.

9) What aspect in the course was not helpful to you?

10) Tell me about how this aspect was not helpful to you.

Once they have started talking about the learning supplement, I will begin questions about the online learning supplement. I will have to repeat questions 11-14 for each component that they mentioned in the interview questions 1-10.

11) Describe to me what you perceive the purpose of <u>(fill in one of the components)</u> component.

12) Tell me how you used this component when working on technical calculus.

13) Tell me about the different locations that you used this component?

14) Tell me how the component was helpful to you this semester.

Some questions pertaining to all the components

15) Talk to me about the components of the learning supplement that were the most helpful and what about the components made them helpful to you.

16) Talk to me about the components of the learning supplement that were not so helpful and what about the components made them not so helpful to you.

17) Tell me what you would improve if you were designing the supplement.

18) Tell me about how the learning supplement as a whole has helped you in the course.

19) Tell me what others have said about the learning supplement.

20) *Describe to me the effect that the TCLS has had on your homework scores.*

21) *Describe to me the effect that the TCLS has had on your exam scores.*

22) *Describe to me how the TCLS has contributed to your overall understanding of the concepts in Technical Calculus.*

23) *In your opinion how would you be doing in this course if you did not use the TCLS?*

24) *The TCLS has helped you, in your opinion, to make an overall grade of ___ and in your opinion without the TCLS you would be make an overall grade of ____. Tell me why are there differences in your performances. (Or I will ask "Tell me why the TCLS has not helped you perform better.")*

25) *In what ways has your experiences changed in this class versus a previous math class that you have had.*

26) *What are the reasons for this change? (Or I will ask Explain to me why your experiences has not changed?)*

Questions to interviewees that have not seemed to used the supplement at all or very little.

27) Tell me about your experiences with the online learning supplement for technical calculus. (*from this question it should be clear if they did indeed use the online learning supplement; if they did not have any experiences with the supplement then follow this question up with question 21; otherwise ask which components did they use and go back to question 11*)

28) Were you aware that there is an online learning supplement available for this course?

29) We find a lot of students do not use the learning supplement. Describe your reasoning for not using the supplement.

30) When buying your textbook you have the option of buying a solutions manual that gives answers to all the odd problems. Explain how you use, if you do, the solutions manual for this course.

31) Compare the solutions manual and the TCLS.

32) Describe to me what you would recommend to a friend, who is taking this course next semester, with respect to the discussion sessions and online learning supplement. (*The idea for this course is to see what they think in hindsight after going through the course and not taking advantage of the online learning supplement or discussion sessions;* ***also I will use this as a question to ask near the end of the interview to interviewees that have used the learning supplement and/or attended the discussion sessions)***

The following are general questions to interviewees who have attended the discussion sessions.

33) What aspects of the discussion sessions are the most helpful to you?

34) What aspects of the discussion sessions are not helpful to you?

35) Tell me about how the discussion sessions helped you in the course.

36) Tell me what others have said about the discussion sessions.

37) Tell me about some of your reasons that you attended the discussion sessions.

General questions about the learning supplement system.

38) If you were given the choice of implementing this type of system in other courses, what types of courses would you use such a system with?

39) Describe to me your overall thoughts about the learning system that we have used this semester.

40) As we end the interview, would you like to comment about anything else?

I will end the interview by saying "Thank you very much for your time and your willingness to talk with me today."

APPENDIX E

INDIVIDUAL CONSENT FORM

Consent Form for Participation in Qualitative Study of Math 2123:

Students Reactions to Working with an Online Learning Supplement Through Weekly Group Sessions to Improve their Performance in Technical Calculus: A Pre-study in Math 2123.

Project Description

To help students in Math 2123, an online learning supplement was developed in 2001. The online learning supplement has different components such as: algebra review, study skills, calculator programs, real life applications, examples of problems similar to homework, and trigonometry review. This research study conducted through Oklahoma State University is an attempt to work with students during afternoon and nightly discussion sessions on their homework and to study what students' impressions of the online learning supplement are through interviews and observing students progress in the course. The interviews will be given near the end of spring 2005 with the students that have participated in the sessions. The underlying idea is that these students with a good understanding of homework and the concepts in technical calculus will do better in the class and more descriptive data can be collected through qualitative techniques. The data that will be used in this study will be interviews, questionnaire, and observation of students' exams. The research study will last from mid January though the pre-finals week at the beginning of May, 2005. This study will benefit students by helping them with their Math 2123 homework, helping them to prepare for quizzes and exams, helping them to have a better conception of course concepts, and maybe helping them receive better grades in the course.

I, ______________________________, hereby authorize David Miller to look at mathematics background and course progress in Math 2123 Section 1 or Section 2, Spring 2005 as part of the study and to interview me during the course of the study.

I understand that interviews and course progress could be used in the write up of his dissertation, but I will not be identified in anyway that the interviews can be linked to me.

____________________________________.

Signature

Choosing not to participate in these interviews will in no way affect my grade for this course and the results of these interviews will be confidential and used only to document students learning in the course.

I understand that participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty after notifying David Miller by phone at 744-2241 or by e-mail at millerd@math.okstate.edu . For information on subject's rights, contact Dr. Carol Olson, IRB Chair, 415 Whitehurst Hall, (405)744-5700.

APPENDIX F

AUDIO CONSENT FORM

Audio Tape Release Form

I voluntarily agree to be audio taped during the inquiry being conducted by David Miller. I understand that the tapes will be used only for analysis of the interviews and only the principal investigator will have access to them. These tapes will be identified by respondent numbers. The tapes will be kept for two years and will be stored in a locked file cabinet in the office of the principal investigator.

______________________________ __________________
Signature of the Respondent Date

______________________________ __________________
Signature of the Investigator Date

Refusal to be Taped

I do not agree to be audio taped during this inquiry conducted by David Miller. By refusing to be audio taped, I understand that I may continue to participate in the study and that David Miller will be writing down notes during the interview, documenting my responses to the questions.

______________________________ __________________
Signature of the Respondent Date

______________________________ __________________
Signature of the Investigator Date

APPENDIX G

IRB APPROVAL FORM

Oklahoma State University Institutional Review Board

Date:	Tuesday, September 13, 2005
IRB Application No	AS0610
Proposal Title:	Students Reactions to Working With an Online Learning Supplement Through Weekly Group Sessions to Improve Their Performance in Technical Calculus
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 9/12/2006

Principal Investigator(s)

David Allan Miller	Dennis Bertholf
2119 W. Noble Road	437 MS
Stillwater, OK 74075	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☐ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 415 Whitehurst (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

VITA

David Allan Miller

Candidate for the Degree of

Doctor of Philosophy

Thesis: STUDENTS REACTIONS TO WORKING WITH AN ONLINE LEARNING SUPPLEMENT THROUGH WEEKLY GROUP SESSIONS TO IMPROVE THEIR PERFORMANCE IN TECHNICAL CALCULUS

Major Field: Mathematics with Specialization in Math Education

Biographical:

Personal Data: Born September 1, 1970 in Columbia, Missouri.

Education: Graduated from Parkview High School, Springfield, Missouri in 1989; received Bachelor of Science degree in mathematics and engineering physics from Missouri State University, Springfield, Missouri in May 1994; received Master of Science degree in Applied Mathematics from Oklahoma State University in December 1998. Completed the requirements for the Doctor of Philosophy degree with major in Mathematics at Oklahoma State University in July 2006.

Experience: Has taught the mathematics courses as a graduate student at Oklahoma State University from 1994 to 2004 and as an Instructor at Oklahoma State University from 2004 to 2006.

Professional Memberships: Kappa Mu Epsilon, Sigma Pi Sigma, MAA, AMS.

Name: David Allan Miller Date of Degree: July, 2006

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EVALUATING THE EFFECTIVENESS OF A LEARNING SYSTEM FOR TECHNICAL CALCULUS

Pages in Study: 240 Candidate for the Degree of Doctor of Philosophy

Major Field: Mathematics

Scope and method of study. The purpose of this qualitative and quantitative study was to describe the perceptions and experiences of participants that attended discussion sessions and/or used the Technical Calculus Learning Supplement (TCLS). This study also investigated the D-F-W rate, class attendance, and pre and post-algebra assessment scores between the participants and non-participants. Each participant completed a questionnaire over the TCLS, a questionnaire over the discussion sessions, pre/post algebra assessment, and a long interview with the researcher. In addition, the researcher recorded daily hits to each of the TCLS components using website counters.

Findings and conclusion. Students used the learning assessment measures (LAMS) the most out of any of the six components of the TCLS; followed by the how to study mathematics; quick algebra review (QAR); quick trigonometry review (QTR); how to use the TI-83 calculator; and the applications from engineering technology components. Students revealed six different reasons why they used the TCLS website and revealed various reasons why they used each of the six components of the TCLS. Furthermore, participants and non-participants expressed nine different reasons why they did not use the TCLS during the semester. Other participants and non-participants stated three reasons why they used the TCLS in a more limited way.

Participants earn a significantly higher mean course grade than did non-participants. For those students that did not withdraw or quit coming to class, participants missed significantly fewer days in class than did non-participants. The results of this research showed that there was no significant difference in the pre-algebra assessment scores for participants and non-participants, nor was there any significant difference in the gain from the pre to post-algebra assessment scores for participants and non-participants.

The students revealed ten reasons why they attended the discussion sessions during the semester. Other students stated seven reasons why they did not attend the discussion sessions. Students attributed much of their success in the course to the three-step method that was used in the discussion sessions and stated that the discussion sessions helped them be more actively involved in their own learning. The students stated six different ways in which the discussion sessions helped them in the course.

ADVISER’S APPROVAL: ____