To the Graduate Council:

I am submitting herewith a dissertation written by D. Sharon Husch entitled "An Investigation of the Relationships between Learning Styles, Personality Temperaments, Mathematics Self-Efficacy, and Post-Secondary Calculus Achievement." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

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AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN LEARNING STYLES, PERSONALITY TEMPERAMENTS, MATHEMATICS SELF-EFFICACY, AND POST-SECONDARY CALCULUS ACHIEVEMENT

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

D. Sharon Husch

May, 2001

DEDICATION

This dissertation is dedicated to

Dr. Donald J.Dessart,

my major professor,

and

Dr. Lawrence S. Husch, Jr.,

my husband,

who supported and encouraged me throughout my academic endeavors.

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Special thanks go to Dr. Don Hinton, Dr. Lawrence Husch, and the students in their classes for agreeing to participate in this study. Their cooperation and participation enabled me to complete my research.

ABSTRACT

With the availability of the internet, many web-based tutorials, and related materials and computer based tutorials, students continue to fail and/or do poorly in calculus classes. On average about fifty percent of students receive a grade of D, F, or W (withdraw) in first semester calculus at the university level. To meet the needs of all students, regardless of learning style, attitude towards mathematics, or ability level, teachers should utilize modern technology, such as computers or graphing calculators. These tools are able to serve the needs of the students in ways that other tools have not been able to accomplish.

The primary purpose of this study was to determine the relationship between learning style preferences, personality temperament types, and mathematics self-efficacy on the achievement and course completion rate of a sample of the University of Tennessee at Knoxville college students enrolled in first and second semester calculus classes which utilized web-based materials. The following research questions were explored.

1. How does student achievement vary with learning style preferences?
2. How does student achievement vary with temperaments?
3. How does student achievement vary with mathematics self-efficacy?
4. How does student achievement vary with teaching method?

To achieve the purpose of this study, five instruments were used to collect data from students enrolled in a lecture/recitation and a web-based first semester calculus class and a lecture/recitation and a web-based second semester calculus class for a total of four classes.

The data collected included ACT mathematics scores, Myers-Briggs personality types, mathematics self-efficacy scores, and calculus test scores. Findings were significant for several dimensions of learning style and temperament with respect to both the calculus test and the Mathematics Self-Efficacy instruments. Students who were categorized as reflective learners on the Felder-Silverman Index of Learning Styles scored significantly higher on the calculus test and those students who were categorized as SPs on the Myers-Briggs Type Indicator scored significantly lower on the calculus test and the Mathematics Self-Efficacy Scale (MSES). Additionally, with one exception, the students who enrolled in the second semester calculus classes were visual rather than verbal learners. The female students declined in enrollment by fifteen percent between the first and second semester of calculus. The expectation was that the web-based tutorials would be an effective means of meeting the needs of the large percentage of visual learners; however the quantitative data were insufficient to test this hypothesis. The survey data indicated that the majority of the visual learners attributed the website as the "aspect that contributed most to their learning."

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Chapter I

INTRODUCTION

The National Center for Education Statistics (NCES) released the NAEP (National Assessment of Educational Progress) 1996 Mathematics Report Card for the Nation and the States on February 27, 1997. The report presented the national results for 4^{th}, 8^{th}, and 12^{th} grade students and state results for 4^{th} and 8^{th} graders. The assessment found approximately 15% of the nation's 12^{th} graders performing "at or above proficiency."

In September, 1991, The Carnegie Commission on Science, Technology, and Government published "In The National Interest: The Federal Government in the Reform of K-12 Mathematics and Science Education" (1991) in which it stated:

> …shortages of American scientists, engineers, and technicians are vivid and convincing testimony that our public school system is failing to prepare all our young people for the future, and that this failing is particularly serious – in both degree and consequence – in mathematics and science." The Task Force further stated that "there is…a serious problem with U.S. mathematics education when 47% of our nation's seventeen-year-olds cannot convert 9 parts out of a 100 to a percentage…A school system where graduates are ignorant about science,

> repelled by mathematics, and confused by technology is a system that is not working well. Many refer to this state of affairs as a crisis … become chronic.

In September, 1989, an education summit took place in Charlottesville, Virginia, in which President Bush and the 50 governors made a commitment that by the year 2000 the U.S. students would be "first in the world in science and mathematics achievement" (Burgoyne, 1998). As a result of these reported findings and recognition of a crisis in our educational system, educational initiatives began; however, the collegiate mathematics courses continue to experience large percentages of student failures and/or withdrawals. At the University of Tennessee, Knoxville, approximately 40-50% of the first semester calculus classes receive grades of D, F, or W (withdraw). Yates (1994) of Southern Oregon State College reported that in Winter quarter, 1993, he observed 50%-75% of his calculus students attain grades of D, F, or W. He further stated that he was convinced that the old way (lecture/recitation) of teaching does not work.

January 25, 1994, Congress passed the Goals 2000: Educate America Act that stated

> … by 2000 students will leave grades 4, 8, and 12 having demonstrated competency over challenging subject matter including …mathematics, and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our Nation's modern economy.

The year is now 2000, and the nation's educational system has fallen far short of the goals set by the Goals 2000: Educate America Act, as reported by the NAEP "Report Card."

Students continue to leave high school deficient in mathematics and science, and many of those students who enter college calculus classes are severely lacking in basic algebra skills necessary to ensure that they succeed in these classes. Research dollars have been spent to develop programs to address the needs of the students in both K-12 and college classrooms yet failure rates continue to be high. The time has come to spend research dollars in areas of brain research and learning styles with respect to calculus students. Reports are showing a correlation between learning styles and/or personality types and student performance. Statistically rigorous long-term studies need to take place in these areas.

Mathematics educators, as a general rule, are not trained in the areas of brain research, cognitive psychology, or control theory, and present methods of research appear to be deficient in ways to impact the problem. As you will see in Chapter 2, The Review of the Literature, the characteristics of the students in college calculus classes have changed considerably in the last 80 years, yet the teaching methods have remained the same. There appears to be a mismatch in teaching styles and learning styles that may account for a large part of these high failure rates.

The Problem

With the availability of the internet, many web-based tutorials, and related materials and computer based tutorials students continue to fail and/or do poorly in calculus classes. What is it about the students and/or the classes that preclude student usage of such materials? Gardner (1983) suggested Multiple Intelligences may be the issue. Myers (1988) indicated that the Myers Briggs Personality Type (MBTI), one form of a learning styles inventory, could be a contributing factor. Those who study learning styles argue that the needs of the learners are not being met.

When such high percentages of college/university students are unable to successfully complete their mathematics classes, we must pursue an understanding that could enable the nation to alter this state of affairs. Why do so many college/university students fail their calculus courses? Is the reason for failure the teaching method as Yates (1994) suggested or the lack of proper mathematics background from the K-12 school years as reported by the Carnegie Task Force (1991)? Claims have been made that the reasons for these large failure rates in mathematics are related to a "mathematics learning disability," a lack of propensity for the subject matter, and/or the students' personality types and/or learning styles. To meet the needs of all students, regardless of learning style, attitude towards mathematics, or ability level, teachers should utilize modern technology, such as computers or graphing calculators. Geisert and Dunn (1990) admonish: " technology is a tool that serves the needs of education in a way that no other tool can." They further stated that educators must learn to combine computer usage with learning preference in a meaningful way to enable students to succeed.

Purpose

The primary purpose of this study was to determine the relationship between learning style preferences, personality temperament types, and mathematics self-efficacy on the achievement and course completion rate of a sample of the University of Tennessee (UTK) college students enrolled in first and second semester calculus classes which utilized web-based materials. The following research questions were explored.

1. How does student achievement vary with learning style preferences?
2. How does student achievement vary with temperaments?
3. How does student achievement vary with mathematics self-efficacy?
4. How does student achievement vary with teaching method?

Importance/Need of the Study

The nation needs researchers actively pursuing methods to address the issue of poor performance in mathematics classes for all levels. Many mathematics professors who attend conferences such as the yearly meeting of the International Conference of Technology in Collegiate Mathematics (ICTCM) have reported that they have "agonized" over ways to improve their teaching and/or help the students to achieve more understanding and better grades. We must turn our attention to the study of students with poor performance to ascertain what can be done to help them improve, and, thereby, help the nation achieve its educational goals.

Computer software and web-based materials for calculus topics abound. So, why aren't the students' grades improving? Professors of mathematics report that they spend many hours in the development of web-based calculus materials for their calculus classes yet their classes continue to have high failure and/or drop rates.

Two factors of importance are 1) to discover the instructional design methods for presenting these materials via the web, and 2) to determine the combination of teaching methods and computer usage that is appropriate for each learner. This study addressed the issue of web-based material utilization with respect to personality temperament types and learning styles.

Assumptions

The following assumptions were present in this study:

1. The students were honest and conscientious in completing the surveys and self-report instruments.
2. The Learning Styles Inventory is accurate in determining each student's learning style.
3. The researcher did not bias the students in the interviews.
4. Using calculus classes of professors familiar to the researcher did not bias the results.

Limitations

The following limitations were present in this study:

1. The gathering of learning style data was limited to one instrument.
2. The gathering of personality temperament type was limited to the Myers-Briggs Type Indicator (MBTI).
3. The study was limited to those students enrolled in the University of Tennessee, Knoxville calculus class utilizing the web-based materials, Visual Calculus, and one lecture/recitation class during fall and spring semester of the school year 1999-2000.

Definition of Terms

The following is a list of terms and the respective definitions used in this study.

Learning Style

The National Association for Secondary School Principals (NASSP) Task Force defined learning style as "the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment." (Keefe et al., 1986).

Active Learners

Active or kinesthetic learners retain and/or understand information by doing something active, such as discussing, explaining, or experiencing. These learners prefer group work to sitting through lectures.

Reflective Learners

Reflective learners prefer to think quietly about information. They tend to be loners and do not like group work.

Sensing Learners

Sensors like learning facts and performing well-defined tasks. They are good at memorizing facts and are practical and do not like courses of study that are not relevant.

Intuitive Learners

One who is an intuitive learner is content to discover possibilities and relationships and likes innovation. They are quite comfortable with abstractions and mathematical formulations.

Visual Learners

A person who is a visual learner remembers best when he/she can see a picture, diagram, flowchart, film, or demonstration.

Verbal Learners

Verbal learners obtain their information through spoken or written explanations.

Psychological type

Psychological type is a term defined by Carl Jung (Melear, 1989) that describes fundamental differences among individuals. What is important is our preference for how we "function." Our preference for a given "function" is characteristic, and so we may be "typed" by this preference. Thus Jung invented the "function types" or "psychological types." In this study, the psychological type or personality type will be determined by the Myers-Briggs Type Indicator (MBTI).

Myers-Briggs Type Indicator (MBTI)

The MBTI is an instrument to describe one's personality type, based on the psychological type theory of Jung. Four dimensions of the personality are scored (See below.) resulting in sixteen different personality types – ISTJ, ISFJ, INFJ, INTJ, ISTP, ISFP, INFP, INTP, ESTP, ESFP, ENFP, ENTP, ESTJ, ESFJ, ENFJ, AND ENTJ. The sixteen personality types can then be grouped into four temperaments of NF, NT, SP, and SJ. For a more detailed explanation of the personality types and the respective temperaments see Appendix A

Mathematics Self-Efficacy

Mathematics self-efficacy is defined to be the confidence a person has in his/her ability to learn and do mathematics.

Test Reliability

A test is said to be reliable if it measures results consistently, i.e. if the test measures the true state of being rather than random aspects of a trait or ability. Various statistical tests exist to determine test reliability.

Test Content Validity

Test content validity is the extent to which a test measures the intended objectives over the domain. An accepted method of establishing content validity of a test is to solicit expert opinion.

Hypotheses

1. Null Hypothesis: There are no significant differences in the mean ACT mathematics scores for the first and second semester calculus students with respect to the four individual temperaments. This hypothesis will be tested using a 3-way ANOVA. (Semester by Teaching Method by Temperament)
2. Null Hypothesis: There are no significant differences in the mean ACT mathematics scores for the first and second semester calculus students with respect to the four learning styles. This hypothesis will be tested using a 3-way ANOVA. (Semester by Teaching Method by Learning Style)
3. Null Hypothesis: There are no significant differences in the mean grades for first and second semester calculus students with respect to the four temperaments. This hypothesis will be tested using a 3-way analysis of covariance (ANCOVA), utilizing the Mathematics ACT score as the covariate. (Semester by Teaching Method by Temperament)
4. Null Hypothesis: There are no significant differences in the mean grades for first and second semester calculus students with respect to the four learning styles. This hypothesis will be tested using a 3-way ANCOVA utilizing the

Mathematics ACT score as the covariate. (Semester by Teaching Method by Learning Style)

5. Null Hypothesis: There are no significant differences in the mean Mathematics Self-Efficacy Scores (MSES) for first and second semester calculus students with respect to their temperaments. This hypothesis will be tested using a 3-way ANOVA. (Semester by Teaching Method by Temperament)
6. Null Hypothesis: There are no significant differences in the mean Mathematics Self-Efficacy Scores (MSES) for first and second semester calculus students with respect to their temperaments. This hypothesis will be tested using a 3-way ANOVA. (Semester by Teaching Method by Learning Style)

Organization of the Study

This study is composed of five major chapters. Chapter I includes the introduction to the study, as well as, the statement of the problem, the purpose of the study, the limitations, hypotheses, and lastly the organization of the study. Chapter II contains the review of the literature, Chapter III contains the methodology and procedures used in the study, Chapter IV contains the results of the data analysis of the study, and Chapter V contains the conclusions of the study and recommendations for further research.

Chapter II

REVIEW OF THE LITERATURE

Introduction

> Mathematics isn't exactly known as academe's most progressive discipline when it comes to curricular reform. Students are still taught to plug in numbers and chug through a formula, and some undergraduates never learn how calculus relates to other disciplines, much less the real world (Wilson, 2000).

Wilson (2000) further stated that "[t]he math curriculum at most universities was designed to appeal to traditional math majors, with a heavy focus on theory and formula manipulation." With this type of teaching and focus, it is no surprise that many students of the 1990s performed miserably in college calculus classes. Husch (2000) reported that approximately 40% of the students enrolled in the first semester calculus class at The University of Tennessee in fall semester, 1999, made grades of D, F, or W (withdraw). Other universities report similar rates of failure (Bogley et al., 1996; Yates, 1994). Husch described the profile of the typical calculus student at the University of Tennessee, Knoxville, as considerably different than that of the past.

> Twenty years ago, the freshman calculus class consisted primarily of engineering, science, mathematics and computer science students; the students who had calculus in high school were in the minority. Familiarity with calculators and/or

> computers was minimal and the failure rate (measured by the number of D's, F's and W's) was approximately 10%-15%. Today, the percentage of engineering, science, mathematics and computer science students is often less than 50%. Between 70% and 80% of the class has had calculus in high school. Familiarity with calculators and/or computers is universal and the failure rate is 40%-50%. The mathematical background of many freshman calculus students appears to be lacking (Husch, 2000).

Repeatedly, professors have reported similar situations with high failure rates. In fact, the national average for state colleges and universities appears to be consistent with the 40%-50% failure rate experienced by the University of Tennessee department of mathematics (Davis, et al., 1986; Rodi, 1986). In Douglas's (1986) words, "to speak of a 'calculus crisis' would not be overly dramatic."

Further evidence of this crisis in collegiate mathematics was demonstrated in the actions of the administrators at the University of Rochester. Four years ago, they proposed deleting the mathematics Ph.D. program and reducing the number of mathematics professors by one-half. Through extraordinary efforts, the graduate degree survived, and the cuts were limited (Wilson, 2000). In order to keep abreast of the changing role of mathematics in society, Harvard developed six courses to fulfill their quantitative reasoning requirement. Many of the Harvard professors felt uncertainty with respect to this requirement because "math requirements scare people." Olsen (2000) reported that the California State University system resorted to using online courseware to enable their poorly prepared students of mathematics to improve. The California State system spends $10 million a year to help its students succeed in all college-level classes.

This phenomenon of declining readiness of entry-level undergraduates in mathematics is not specific to the United States. In a 1995 report, the Engineering Council of the United Kingdom (UK), specifically sought to address the declining mathematical fitness of recruits to engineering courses in the UK (Armstrong & Croft, 1999). The Council stated that there exists "a serious lack in technical fluency, the ability to carry out numerical calculations with ease and fluency." Hunt and Lawson (1996) reported a significant decline in mathematical skills over the period 1991-1995 among students in all years of their study. Armstrong and Croft (1999) reported that the staff of Loughborough University also noticed students with declining competencies in "basic and necessary" mathematics skills.

Sells (1980) deemed that mathematics was the "critical filter" in the pursuit of scientific and technical careers. Douglas (1986) of The Mathematical Association of American (MAA) and the State University of New York at Stony Brook stated that "[t]he United States [was] experiencing a shortage of young people studying mathematics, science and engineering." He predicted the shortage would worsen. He stated that "calculus is the gateway and is fundamental to all such study." A few years later, the Carnegie Commission on Science, Technology, and Government echoed these claims. Many have called for reform in the teaching of mathematics.

Thirteen years after Douglas's (1986) admonition of an impending crisis, the National Council of Teachers of Mathematics (NCTM) released a report (1999) stating that students are learning only definitions and simple calculation procedures. The NCTM further reported "…[that] traditional teaching approaches are deficient …"

Epp (1986) summarized studies completed by the Cognitive Development Project of the University of Massachusetts at Amherst by stating, "[t]hey found that a large majority of calculus and post-calculus students tested at universities throughout the country could not set up or even correctly interpret simple proportionality equations." In 1994, three mathematics professors at Tennessee Technological University conducted a study to ascertain the mathematics retention level of "A" and "B" students who were taught calculus in the traditional lecture/recitation manner. Their results were startling! Of the 85 students tested, none could solve problems in which previously learned information was applicable to the new problems. They reported that two-thirds of the students could not solve a single problem correctly, and only a mere 58% showed any progress towards solving any of the problems. Furthermore, the students used arithmetic or algebraic techniques, not calculus, in their attempts to solve the problems (Seldon, Seldon, & Mason, 1994). Certainly their study was confirmation of the NCTM (1994) findings.

Armstrong and Croft (1999) reported that "universities … need to adapt their courses and make special provisions to counter the shortfall in basic math skills." Many researchers have reported abysmal deficiencies in mathematics skills of entry-level college students, and teaching methodologies that fail to meet the students' needs. Researchers reported that teachers have utilized the same lecture/recitation methodology since the early 1900s (Dixon et al., 1998; Stigler & Hiebert, 1997). One would wonder if the state of affairs in teaching and learning calculus could get worse. Until such problems can be abated, it is necessary for universities to adapt their courses and make special provisions to accommodate these students with deficiencies in mathematical skills, or continue to experience high failure rates in calculus classes.

More than 20 years ago, Gordon (1979) admonished the university mathematics professors to be aware of societal pressures and provide students with the means to solve real-world problems. "Not to do this is to do our students a disservice" (Gordon, 1979).

In 1986 a special conference organized by The Mathematical Association of America (MAA) and funded by the Sloan Foundation met to discuss the state of calculus in colleges and universities in the United States. Interestingly, the same claim of poorly prepared students and 50% failure rates experienced then has not changed in the fourteen years since that memorable conference which was the beginning of the Reform Calculus Movement. With the vast amount of resources that have been devoted to changing the state of calculus teaching and to diminishing the percentage of failure rates, it is difficult to understand why the failure rates are not decreasing instead of remaining constant at 50%. Davis, et al. (1986) stated

> Failure rates in many courses are reported at 50% and above. We believe that with a good placement program, with high quality instruction, and a good support structure for a course, failure rates should be below 15%. A failure rate above 15% indicates that there are problems with either placement, instruction, or support structure.

Perhaps this is true; however, it is highly probable that factors other than placement, instruction, and support structures are contributing to this problem.

Mathematics Self-Efficacy

Self-efficacy theory was originally reported by Bandura (1977) and referred to a person's beliefs concerning his/her ability to successfully perform a given task or behavior. The factors that influence this measure are

- Performance accomplishments,
- Vicarious learning or modeling,
- Verbal persuasion, and
- Emotional arousal or anxiety.

Lent (1996) stated that these four sources interact dynamically to affect self-efficacy judgments. Bandura (1977, 1982) stated that performance accomplishments were hypothesized to be the most powerful source of self-efficacy, and that self-efficacy expectations could be learned and/or altered. In fact it was shown that

> task performance significantly and strongly influenced ratings of task self-efficacy, task interest, and global ability ratings. Success experiences produced elevations in self-efficacy, task interest, and ability ratings over time, while failure experiences depressed these same ratings (Campbell & Hackett, 1986).

Utilizing this cognitive theory, Betz and Hackett (1983) developed the Mathematics Self-efficacy Scale (MSES). The MSES is currently utilized both for research and counseling intervention and is intended to measure a person's perception of his/her ability to perform various mathematics related tasks. There have been several iterations of the original MSES and the present scale contains a 34-item questionnaire which yields three scores in the following areas:

1. perceptions of ability to utilize mathematics in everyday tasks and activities,
2. perceptions of ability to complete mathematics and science related college courses with a final grade of "A" or "B", and
3. overall mathematics self-efficacy.

Mathematics self-efficacy is an important factor for the prediction of success of students in mathematics classes (Lent et al., 1993; Matsui, Matsui, & Ornish, 1990; Pedro, et al., 1981; Sherman & Fennema, 1977). College counselors reported that students who believe that they cannot succeed no matter what measure they take will avoid special tutoring sessions or avoid arranging special one-on-one help sessions with their instructors. They will not ask questions for clarification in class nor seek help from instructors during office hours. A student who does not believe that anything he/she does will affect the grade in a positive manner will not take advantage of outside activities specifically designed to help improve understanding of the mathematics. With regard to this avoidance, Pajares (1995) stated that

> Self-efficacy beliefs … strongly influence the choices people make, the effort they expend, the strength of their perseverance in the face of adversity, and the degree of anxiety they experience. In part, these self-perceptions can be better predictors

> of behavior than actual capability because such self-beliefs are instrumental in determining what individuals do with the knowledge and skills they have.

Additionally, mathematics self-efficacy has been reported to significantly contribute to career choices (Post-Kammer & Smith, 1986). According to Betz (1978), mathematics anxiety may be a critical factor in a student's educational and vocational decision and, in addition, may influence the student's achievement of his/her educational and career goals.

> Self-efficacy theory (Bandura, 1977, 1982; Hackett & Betz, 1981) and research investigating the role of mathematics self-efficacy in the career choice process (Betz & Hackett, 1983; Hackett & Betz, 1984) provide support for the view that mathematics-related self-efficacy, as influenced by gender, socialization, and math level and background, is more strongly predictive of math-related major and career choices than ability, math background, or gender alone or in combination… In fact…, at least with college-aged women and men, self-efficacy expectations with regard to occupations and career-related domains are much more important than measured abilities (Hackett, 1985).

The relationship of mathematics anxiety to performance and career choice is undeniable (Fennema, 1980). In studies completed in 1978, Betz (1978) found the following:

- students avoided college majors and careers if an extensive mathematics background was required
- older women reported higher levels of anxiety than did the younger women, and

- high school mathematics preparation strongly influenced a college student's attitude about mathematics.

Tobias and Weissbrod (1980) found that students would stop studying mathematics to avoid having anxiety. Meece et al. (1990) found that "a large percentage of students stop taking mathematics courses by the 10^{th} grade." This action could severely limit the students' educational and career aspirations. They saw this decision as affecting career options for women, and they reported that fewer women than men elect to take advanced mathematics courses in high school, which causes women to continue to be underrepresented in mathematics intensive career fields. With respect to race, Post et al. (1991) found that self-efficacy and confidence played a greater role in selection of career for African-American males than African-American females; however, the African-American males considered a broader choice of careers regardless of whether the field was mathematics or science related.

Other noteworthy researchers pursuing an understanding concerning attitude towards mathematics, reported the following:

- Sternberg (1986) stated that there are many reasons other than intelligence which affect the level of a person's performance,
- Dessart (1989) reported that some educators believe that attitude is more important than ability in predicting success,
- Seigel and Shaughnessy (1992) found that women were more insecure and anxious than men in calculus classes,

- Goleman (1994) stated that at best IQ accounts for only 20% of the life factors that determine life successes,
- Shaughnessy et al. (1994) found that significant predictors of success in calculus were "exacting in character, persevering, responsible, and conscientious" individuals, and
- Shaughnessy, et al. (1995) found that the personality factors of "privateness, intelligence, and emotional stability" contributed to the prediction of college calculus grades.

There is much to be learned from the cognitive theorists regarding the influence of self-efficacy on both high school students and college students with respect to level of mathematics courses taken and to career choices made. The researchers reviewed here emphatically urged educators of mathematics to take heed and understand that mathematics ability is secondary to the student's perceptions (self-efficacy) of how well he/she can perform. Mathematics educators must understand that the student's perception is his/her reality. This body of evidence should be enlightening to educators who have been unable to understand why students fail to meet their expectations with regard to asking questions for clarification and/or participating in extra help sessions. This would explain why the educators holding office hours rarely see the students who need the most help. In the students' minds, nothing will help, and they are doomed to fail!

Learning Styles

> Colonial colleges, whose mission centered on the moral preparation of civic leaders, relied on the residential campus to create a community of shared values. Shifting the emphasis of institutional mission to the practical application of knowledge, the land-grant movement used the lecture as an efficient mechanism for professors to share the results of their research. The teaching … that emerged remains the predominant pedagogical model at most of our campuses today (Twigg, 1994).

Although the pedagogy has not changed, the student has! At the turn of the century, less than one percent of the population, approximately 232,000 students, attended college (Twigg, 1994). Furthermore, this population consisted primarily of young, elite, Caucasian males (Smith, 1999; Twigg, 1994). By the beginning of World War I, the number of undergraduate college students had increased to 1.4 million, and by 1994, there were 13-14 million college students in the United States. No longer are the students predominantly Caucasian, elite males. Today's college students are diverse in all areas. With respect to undergraduates, only 43% are reported to be under the age of 25; women make up 55% of the population, and more than 16% are nonwhite. Students come from all socioeconomic backgrounds. Every campus possesses large numbers of "nontraditional students" who are older, working adults returning to school for the purpose of broadening their knowledge base. In the past, the college education was viewed as preparation for a lifetime career in which mastery of a body of knowledge was expected. Presently, the college education is viewed quite differently. Companies seek to hire graduates who possess interpersonal skills and are able to work as a team member, those who can think critically, reason quantitatively, possess effective communication skills, able to locate information, and have the capacity to learn (Twigg, 1994).

As the total college population has changed over the years, so also has the population of students studying calculus changed. Husch (2000) stated

> … the best freshman mathematics students receive advanced placement credit for calculus and, consequently, start with the sophomore level courses in mathematics if they study mathematics in college. There have been significant changes in the teaching of high school mathematics; there is no longer a "typical high school background" in mathematics.… In addition, [there are] a significant number of students from areas outside of engineering, science, mathematics and computer science.

With the drastic change in the characteristics of the students attending institutions of higher education, educators must be willing to change and/or augment their teaching practices, also. A problem exists when students have changed but teaching practices have not.

> Most teachers tend to rely almost exclusively on sequential, verbal presentations, combined with private reading [and] writing activities.… Student[s] [are expected] to think in complex ways before completing a project, in fact they are often exposed to only a narrow approach to our subject matter. The loss of

> opportunities to engage in our subjects from a variety of orientations becomes an obvious flaw to those who recognize the inevitability of diverse points of view in the world. Even worse, we can trace lack of motivation, resistance, misperceptions, failure, and uninspired intellectual work to the fact that many students cannot learn well within the limited orientation provided them in the classroom (O'Connor, 2000).

Papert and Negroponte (1996) expressed the belief that almost all students have the ability to learn most concepts. Papert claimed that the bell-shaped curve applied not to the normal distribution of IQ, but instead to the distribution of time it takes a person to learn a given concept. Obviously, students in higher education have time constraints placed on them for learning; however, enriching the classrooms to meet the needs of today's diverse student population characterized by significantly different learning styles could abate the dismal failure rates in the mathematics, science, world languages, and various engineering departments.

"Learning style theory" is a body of research that refers to the fact that an individual perceives and processes information differently. Leaver (1997) stated that "learning styles are characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with and respond to their learning environment." Deis (2000) claimed that these styles are divided into the four areas of

1. environmental preferences

2. sensory modalities, i.e. visual, auditory, and tactile learning, as well as, individual or group learner
3. personality types, and
4. cognitive styles, i.e. the manner in which a person processes new information.

Some researchers consider only the sensory modalities while others include the sixteen personality types defined by Myers (1980). The Felder-Silverman Learning Styles Model developed and used extensively with engineering students classifies learning styles into five dimensions, two of which correspond to the Myers-Briggs dimensions. (Felder, 1996). See Table 1 for a listing of these dimensions and the respective preferences.

A cursory glance at the literature, an ERIC document search, or an internet search yields vast quantities of information concerning learning styles. This research was limited to the Felder-Silverman Learning Style Model for several reasons.

- The Felder-Silverman inventory was designed "with dimensions that should be particularly relevant to science education," (Felder, 1988) and the academic culture of mathematics is thought to be similar to that of the physical sciences; therefore, the dimensions should also be relevant to mathematics education (Husch, 2000).
- The inventory has been utilized extensively with engineering students at several universities including North Carolina State University, University of Western Ontario (Fielder, 1996), the University of Michigan (Montgomery, 2000), and at Louisiana Tech University.

Table 1

Dimensions of the Felder-Silverman Learning Style Model

Sensing Learners • Concrete • Practical • Fact oriented • Likes procedures	Intuitive Learners • Conceptual • Innovative • Theory oriented • Likes abstractions
Visual Learners Prefer • Pictures • Diagrams • Flowcharts	Verbal Learners Prefer • Written explanations • Oral explanations
Inductive Learners Prefer • Presentations that move from specific to general	Deductive Learners Prefer • Presentations that move from general to specific
Active Learners Prefer • Trying things out • Working with others	Reflective Learners Prefer • Thinking things through • Working alone
Sequential Learners Are • Linear • Orderly • Learn in small incremental steps	Global learners Are • Holistic • Systems thinkers • Learn in large leaps

Other models of learning styles utilized in the sciences but not discussed here include the Kolb's Learning Style Model and the Herrmann Brain Dominance Instrument (Felder, 1996).

Schroeder (1993) pointed to a fundamental "mismatch" between the preferred learning styles of faculty and those of students. He indicated that 75% of the faculty preferred intuitive learning while less than 10% preferred the concrete active pattern. Conversely, 50% of the high school senior population reported a concrete active preference for learning and less than 10% preferred the abstract reflective style of learning. Additionally, Montgomery and Groat (2000) reported that women engineering students were more prone to be active learners. Felder (2000) stated that active learners have a particularly hard time sitting through lectures and taking notes, yet this method is frequently employed by many collegiate educators. Montgomery and Groat (2000) stated that it is not realistic to expect faculty members to develop teaching methods to meet the individual needs of all students; however, they suggested that faculty should strive to provide a variety of learning experiences and thereby address more learning styles.

Why should a faculty member expend the time and energy required to undertake such an endeavor? Smith (1999) claimed that those who will utilize this body of research to design educational programs to fit students' learning needs will experience programs that "lead to greater learning gains, higher satisfaction for both students and teachers, and greater persistence in pursuing educational goals." Although not limited to calculus classes, Sullivan (1993) conducted a meta-analysis of 42 experimental research studies and reported that improvement in academic outcomes could be expected 75% of the time. However, Felder (1996) cautioned

> If professors teach exclusively in a manner that favors their students' less preferred learning style modes, the students' discomfort level may be great enough to interfere with their learning. On the other hand if professors teach exclusively in their students' preferred modes, the students may not develop the mental dexterity they need to reach their potential for achievement in school and as professions.

According to Montgomery and Groat (2000), those whom utilized this body of information experienced more rewarding happenings in the classroom and experienced enhanced student learning. Griggs (1991) found the greatest benefit from attending to learning styles in mathematics or science education was that of placing more responsibility on the students for their own learning. Students who have discovered and understood their individual learning styles and preferences and have applied the information, did so with great success and enthusiasm. Carruthers et al. (1999) also found this to be true with students in their calculus classes. Tobias (1990) reported that the poor quality of introductory college science instruction could be expressed directly as a failure to address diverse, learning styles. Researchers have indicated that addressing learning styles and personality types can make learning more productive for women, minorities, and nontraditional, older students (Banks, 1988; Belenky, 1986; Knowles, 1980; Melear, 1994; Montgomery & Groat, 2000).

O'Connor (2000) warned that educators must realize that students in their classrooms possess diverse learning styles, and they will be unsuccessful when limited to those activities that are incompatible with their preferred mode of learning. These and many other researchers admonish educators to be aware of the diversity of students in their classrooms. Likewise, they insisted that making the effort to address these issues could be a rewarding experience for all, but more than that, educators must remember that

> Tomorrow's students will resemble today's research faculty and will possess qualities of increased independence and self-reliance. No longer will students be passively taught by teachers who organize the learning experience for them. Students will learn how to find and use learning materials that meet their own individual learning needs, abilities, preferences, and interests; they will learn how to learn. Faculty will encourage and guide students to use the rich information resources available to students and to work collaboratively when appropriate (Twigg, 1994).

Personality Types and Temperaments

> If I do not want what you want, please try not to tell me that my want is wrong.
> Or if I believe other than you, at least pause before you correct my view.
> Or if my emotion is less than yours, or more, given the same circumstances, try not to ask me to feel more strongly or weakly.
> Or yet if I act, or fail to act, in the manner of your design for action, let me be.

> I do not, for the moment at least, ask you to understand me. That will come only when you are willing to give up changing me into a copy of you….
>
> If you will allow me any of my own wants or emotions, or beliefs, or actions, then you open yourself, so that some day these ways of mine might not seem so wrong, and might finally appear to you as right—for me. To put up with me is the first step to understanding me. Not that you embrace my ways as right for you, but that you are no longer irritated or disappointed with me for my seeming waywordness. And in understanding me you might come to prize my differences from you, and, far from seeking to change me, preserve and even nurture those differences (Keirsey & Bates, 1984, p. 1).

This plea to be understood and accepted applies to many people. Approximately 400 B.C. Hippocrates recognized the fundamental differences in personalities of people. He is credited with being the first to observe and categorize these differences. In the twentieth century, Ivan Pavlov, John Watson, Sigmund Freud, Alfred Adler, Carl Rogers, Abraham Maslow, and then Carl Jung in 1920 all studied the behavior of people. Some of these have become highly believable and others highly controversial. Presently, many psychologists tend to associate their belief system with either Freud who claimed that people are driven from some instinctual lust or Jung who believed that people have innate differences that motivate them. Melear (1989) explained Jungian theory as the consistency with which people seemingly act differently, relative to the way in which they take in information, make decisions, form attitudes, and process and assimilate information. Jung stated that people perceive the world in one of two contrasting modes, sensing or intuition, and make decisions relative to this information in two contrasting modes. He further claimed that a person's attitude toward life could be categorized by the judging or feeling dimension, and the manner in which a person draws energy can be observed as introverted or extroverted. Building upon this Jungian psychological type theory, Myers and Briggs (Myers & McCaulley, 1985) developed the Myers Briggs Type Indicator (MBTI) in its present form, a 126-item inventory, in which people are "typed" by their preferences with respect to four bipolar dimensions. These dimensions are:

1. Extrovert (E) – Introvert (I),
2. Sensing (S) – Intuition (N),
3. Thinking (T) – Feeling (F), and
4. Judging (J) – Perceiving (P).

A person, by answering questions about his/her preferences for doing certain tasks, will be grouped into one of the aspects of the four dimensions, i.e. an extroverted (E), sensing (S), thinking (T), judging (J) person would have an MBTI of ESTJ. In like manner, there are 2^4 combinations or sixteen personality types as indicated in Table 2.

During the past 50 years there has been an increase in the use of the MBTI in the areas of education, industry, and business. Industry has spent millions of dollars hiring consultants to "type" their personnel and teach them how to accept and appreciate individual differences in their coworkers. One company, a former employer of the researcher, spent several years and many millions of dollars training the employees to

Table 2

Sixteen Myers-Briggs Personality Types

	Sensing		Intuition		
Introverted	ISTJ	ISFJ	INFJ	INTJ	Judging
Introverted	ISTP	ISFP	INFP	INTP	Perceiving
Extroverted	ESTP	ESFP	ENFP	ENTP	Perceiving
Extroverted	ESTJ	ESFJ	ENFJ	ENTJ	Judging
	Thinking	Feeling	Feeling	Thinking	

work with and to respect people of different races, gender, and personality types. The program was launched in the late 1980s and progressed from "Men and Women as Colleagues" to "Valuing Diversity" and "High Performance Work Systems." Workshops were devised to show the employees through experiential learning that ideas generated with highly diverse types of people working together far surpassed those of all like-minded people. The emphasis placed on valuing the individual for his/her respective contributions to any project impacted the growth of the company to the extent that the stock prices rose from approximately $30/share in 1992 to over $300/share in mid-2000. The CEO of this highly technical company captured a vision of the vast difference a diverse workforce could produce given the proper training, and his foresight proved to be invaluable to the company.

As companies have learned to value the diversity of people, educators also should acknowledge these differences and deal with the reality of facilitating people with differences in their learning styles and/or personality types in their endeavors to learn. With respect to education, several authors (Brightman, 2000; Curry, 1983; Krause, 1997; Melear, 1989; Raiszadeh, 1997) tout the MBTI as the most reliable method for assessing students' learning styles. Krause (1997) stated

> I would strongly recommend that all students be evaluated periodically for learning style, using the Jungian model, as I believe, it more completely encompasses the real differences in learning found in 50 plus years of research, than other models which have been investigated. The Jungian model is able to detect significant differences in student achievement by group membership, and to achieve real differences in student accomplishment with type specific techniques. This is the proof of the model (Krause, 1997).

However, Pittenger (1993) declared that "there is also a large and often conflicting body of research that examines the validity of the test." He further argued that "there is a tradition of skepticism concerning the value of type theories of personality." A conversation with Melear (2000) explained this negative attitude towards the theory of psychological type. It is her belief that psychologists are divided as to their alignment with Jung or Freud; thus the dichotomy of beliefs concerning the MBTI.

This discussion of the MBTI has been limited to its use in education. From the personality types, preferential methods of learning may be identified. This is not to say that students learn in only one manner, it merely suggests that there exist preferences.

Several authors have admonished educators to utilize different modes of teaching for several reasons: 1) to maximize the likelihood appealing to many learning styles, and 2) to prepare the students to enter a workforce where they can be successful.

Although each of the four dimensions is bipolar, the resulting sixteen personality types contain overlapping preferences in some areas. Keirsey (1998) studied the sixteen personality types and observed that they could be grouped into four distinct groups (temperaments) – SPs, SJs, NFs, and NTs – who in his words "[are] light years apart in their attitudes and actions." Due to the limited number of observations in this study, the analyses were limited to the four temperaments as opposed to the sixteen personality types. Given that these four temperaments are "light years" apart, the tests of significance should be more likely to detect differences, if they exist, with respect to the temperaments.

To understand the differences in preferred teaching styles and/or study habits with respect to the four temperaments, refer to Table 3. From the table, one can see that the primary mode of education today, lecture/recitation, was designed for the SJ, only one of four temperaments and represented by only 38% of the population. Perhaps this fact alone can help us understand why the failure rates in calculus classes are approximately 50%.

There are a limited number of studies utilizing the MBTI in calculus classes in higher education. Jamison (1994) studied the effects of several variables, including MBTI on college mathematics achievement on students enrolled in seven classes of pre-calculus at Virginia Polytechnic Institute and State University. She found that the MBTI

Table 3

Learner Characteristics by Temperament

NT Rational	NF Idealist	SP Artisan	SJ Guardian
• Learns best through self-determined study, debates • Frustrated with “details to whole” approach Needs to see the overall concept first • Likes lectures that deal with the abstract • Looks for patterns • Prefers to learn alone first • May tend to take over in a group • Likes pictures, diagrams, etc. to show spatial relationships • Does not memorize easily • Likes puzzles and brain teasers • Pragmatic • Skeptical • Wants recognition of high competence	• Learns best through cooperative learning or one-on-one interactions • Most unique and least understood • Global in perspective • Poetic in nature • Needs to see overall concept first • Does not memorize easily • Can visualize as though having a “photographic” memory • Likes metaphors for learning new information • Imagination is strongest tool • Creative • Altruistic • Wants one to one, caring with affirmation of personal worth • Wants recognition of unique self	• Leans best with demonstrations with action and hands-on work • Favorite activities – hands-on manipulation and personal experimentation • In games, emphasizes fun and competition • Areas of interest are the fine arts, mechanics, and construction • Practical • Optimistic about the future • Cynical about the past • Want to be at the center where the action is • Likes follow-through, but tolerant • Wants recognition for flair, timing	• Learns best with teacher-led question and answer, rote drill and recitation • Needs concrete procedures for analysis • Favorite activities are review, repetition, practice for learning requirements • Likes to read factual and real materials • Emphasizes fairness and rules • Areas of interest are business, health services, and education • Dutiful • Pessimistic • Gateways • Wants clear, fair rules with follow-through • Wants recognition of a job well done

preference of extrovert (E) versus introvert (I) was a significant predictor for the problem-solving test with the introverts averaging eight points higher on the test. The dimension of judging (J) versus perceiving (P) was significant for the algebra skills final examination with those who were Js scoring 11 points higher. She also found that these dimensions were predictors of the course grade. The students with the I__J combination scored 13-20 points higher on the algebra skills final and 11 points higher on the course grade.

Van Voorst (1989) investigated the effects of supplementary instructional activities, learning style, and grouping on students' performance on computational and problem-solving tasks in calculus. He found that students performed better when they worked in groups on traditional materials. He also found a significant three-way interaction of the variables at the $\alpha = 0.10$ level on the retention problem-solving test. He indicated that this result shows a need to consider learning styles in instructional design. Raiszadeh (1997) investigated the relationship between students' MBTI, learning style, and achievement in intermediate algebra at a community college. She found that the MBTI intuitive (I) achieved significantly higher mathematics scores than the sensors (S).

Although this study did not utilize the MBTI with calculus students, Rooney (1991) examined the effect of student and teacher brain dominance on course grades and final examination scores in nine sections of calculus 1. She found that left brain dominant students received statistically higher course grade means than right brain dominant students. She further stated that right brain dominant subjects received three times as many F or W grades. This information can be correlated to the MBTI.

At the college level, Melear (1989) utilized the MBTI with biology students at The Ohio State University. She found that ISTJs and ISFPs were more likely to succeed and those with the E__P combination were more likely to fail. If the biology course required substantial amounts of memory work, this would explain why the SPs and SJs who are better able to memorize information scored significantly higher. Furthermore, this supports the findings of Raiszadeh in community college algebra classes.

Hoffman and Waters (1982) examined completion and attrition rates for a computer-assisted instruction (CAI) course designed to help military students learn and transcribe Morse code. They found that sensing (S) students completed the CAI portion of the program significantly faster than the intuitive student (I). They also found that 58% of those students having the E__P preferences dropped out of the course. They concluded that CAI favored sensing individuals who pay attention to details and are able to memorize facts.

Hadfield and McNeil (1994) utilized the MBTI to study mathematics anxiety among preservice elementary teachers. They found that the feeling (F) preference and age level were significant predictors of mathematics anxiety as measured by the *Phobus Inventory*. They found that 46% of the elementary teachers had the personality types of ENFP, ISFJ, ESFJ, and ISFP. They believe that certain personality types are attracted to the elementary teaching profession and that mathematics anxiety is prevalent in these types. They stated that those who interpret the world in terms of feelings (F) are more prone to mathematics anxiety.

Is the information in these studies useful? Many agree that utilizing these facts would enable educators to better plan their classes. If they know that 24% of their students are likely to have trouble with memory work, they could insert some activities that facilitate understanding. Some argue that technology is perfect for this endeavor.

Computers in College Mathematics

"Although the use of computers and calculators for calculus instruction requires a great amount of effort on the part of the teacher, the potential exists for a learning environment that is more motivational, meaningful, and relevant" (Anderson & Loftsgaarden, 1988). Other mathematics educators agree that using calculators and computers in calculus enables the instructor to emphasize the learning of concepts, to introduce more varied learning experiences, and to present a more meaningful conceptual calculus course (Demana & Waits, 1990; Kemeny, 1988; Porta & Uhl, 1990; Ralston, 1990; Selden & Selden, 1990; Zorn, 1990). Rochowicz (1996) stated that "a technology using environment enables students to apply their knowledge to more relevant and practical situations and as a result students should be better prepared for the future technological job market." He further stated that more challenging problems and exercises would be possible with less focus on the individual skills and routine procedures. However, calculus educators are slow to utilize these technologies due to several factors including the rapidly changing nature of technology and the enormous amount of time and effort it takes to incorporate computers into their teaching. Using technology in the classroom necessitates a change in philosophy about education. The teacher must become more of a facilitator and coach giving the students increased responsibility for their own learning and allowing them to attain more permanent and conceptual knowledge (Gagne, 1985).

Hoffman (1989) investigated the use of computers in a service course of calculus for science and social science students. He revamped the course to include topics that would ordinarily cause a student extreme frustration in doing tedious computations. He stated that "most students see neither beauty nor relevance in the working out by hand of the steady-state solution of a simple-minded, three-state regular Markov process." However, he stated that using 10 or 15 states and performing the calculations on the computer, gives the students the opportunity to not only see the beauty, but the power in the technology. Hoffman (1989) stated: "in much of applied mathematics, the beauty of the underlying structure is increasingly apparent to the students of today, who are relieved of the drudgery of the tedious calculations that took so much time in the 'bad old days.'"

Fawcett (2000) stated that there is considerable research to support that students learn more content and learn it faster with technology when learning is defined "as real world problem solving, finding and using information, and working well with others" rather than the usual definition which emphasizes facts, skills, and content. The RCET was founded in 1999 and emphasizes research in exploring the conditions under which teachers and students use technology for problem solving, inquiry, critical thinking, and the impact on student learning in the preK-16 classes.

A yearly meeting of the International Conference on Technology in Collegiate Mathematics provides the opportunity for mathematics educators from around the world to come together and to learn about the successes and the opportunities for improvement in the utilization of technology in collegiate mathematics classes. Some of the presentations deal with studies that are statistically rigorous, while others are only anecdotal. All conference participants are enthusiastic about the utilization of technology in their teaching. Proceedings from this conference are available online at http://archives.math.utk.edu/ICTCM/ and cover the years 1994 – 1999. All papers in the collection deal with the implementation of calculators, Computer Algebra Systems (CAS), or computers in the collegiate mathematics classroom and the effects of this implementation on the students.

Monteferrante (1995) reported an implementation of computers in their pre-calculus and pre-statistics courses. She stated that fewer than 10% entry level students take calculus while 80% take the aforementioned courses. Their calculus project, Calculus Concepts, Computers and Cooperative Learning (C^4L), has as its goal to reduce the number of D, F, and W grades. They did not attain that goal in the first year; however, they stated this as a long-term goal. They did find that “a dedicated lab provided a location for cross fertilization of mathematical experiences, the kind of intellectual support and camaraderie now recognized to enhance the probability of success in mathematics (Monteferrante, 1995).

Kuntz (1996) reported on his efforts at putting class notes online. Their mathematics department has as its largest contingent students who are not mathematics majors, with the largest group majoring in business. His efforts were to put class notes online that were intended to provide a study outline or commentary on the major topics and vocabulary. He stated that it took him an average of three hours to prepare these notes for each one hour of class time. Results from a questionnaire showed 72% of the students accessed the notes and 86% of those students found them to be helpful. He reported that no one indicated that the notes were of "no value".

Putz (1997) reported on the efforts made to incorporate the use of computers in their calculus program. The efforts there were to utilize a computer algebra system (CAS), Maple, in the traditional program. "The goal was to find ways to help students understand the concepts of calculus better." They developed laboratory assignments to be completed cooperatively. The use of computers for multivariable topics was found to be the most valuable. Results from surveys of the two classes indicated that 71% of the students thought that Maple was helping them learn calculus I, while 86% of the students thought that Maple was helping them learn mulivariable calculus. Furthermore, Putz (1997) stated that he was convinced that utilization of the CAS was the way to teach calculus and he could not imagine teaching without it.

Krishnamani and Kimmins (1995) found "a shift in emphasis from grades to learning concepts" when they incorporated "constructive interactive methods involving computer activities and cooperative learning" into the abstract algebra classes. They also found that "computer activities enabled the teacher to introduce concepts well in advance of when they could otherwise have been introduced and enabled the students to be more familiar with the ideas, abstract and otherwise." The students were no longer studying just to do well on tests, but shifted to "a pattern of continuous learning and having discussions with peers and professors." Some students moved into leadership roles within their groups and retention improved. The authors further stated that "the highlight of using technology was the way students were able to understand cosets and, consequently, predict Lagrange's theorem. They were able to get the sketch of the proof on their own… a vast improvement over the traditional method." Another interesting fact reported was that of impressive performances by students who might have gone unnoticed in traditional classes; those who would have been average to below average excelled. In the calculus class, they found the use of computers allowed the exploration of numeric and graphic interpretations of the fundamental concepts of calculus. They reported that the grades did not improve, but "boredom and inactivity seemed to disappear."

In Australia, in 1988, the Department of Employment Education and Training funded the Introductory Calculus Project, as part of the Education of Girls in Mathematics and Science Program. This project aimed to encourage the interest and participation of all students in calculus, with a particular focus on women. Concerning this project, Barnes (1996) reported that technological tools aid students in developing intuitive understanding of calculus concepts. She reported that graphics calculators or computers provided the student the ability to complete problems that would otherwise be far too laborious. The students worked with graphical representations of motion to see the rate of change of a function. She stated that "ideas [were] communicated much more effectively by using the power of the computer or graphics calculator to process information rapidly and produce powerful visual images."

Avioli (1994) had the following to say about the utilization of computers in the calculus class.

> Maple is used to enhance the teaching of the calculus through illustrations of traditional concepts in the subject, to solve more 'real' problems which involve hard, long, tedious calculations, to permit more time spent on concepts rather than on calculations and, generally, to illustrate to the student that computer software is a valuable tool in a mathematician's tool box of methods to solve problems.

Bogley et al. (1996) reported on the goals and development of the CalculusQuest project funded by the Oregon State System of Higher Education. In fall, 1995, only 50% of their students passed the first term calculus course with a "C" or better. In response to this problem they developed a web-based first term calculus course. Believing that learning styles were of importance, the developers of CalculusQuest incorporated approaches to match different learning styles. After completing a study utilizing technology involving introductory differential calculus classes, Galindo (1995) stated that "appropriate uses of technology may equally benefit students of different cognitive styles." De Lemos (1995) looked at the relationship of learning styles and computer-based instruction in a pre-calculus class. He reported significant improvement of all learning styles (visual, auditory, tactile/kinesthetic) in the sample of pre-calculus students utilizing technology in their class; however, he found that visually motivated students had the largest improvement. Additionally, the tactile/kinesthetic learners had a significant increase in interest and motivation. With respect to motivation of students possessing average ability and low expectations, Barling (1996) reported that improvements [in grades] were modest but students became self-managed and had improved confidence.

Not all mathematics educators reported improvements or significant changes in motivation. Pilant et al. (1999) from a campus with more than 13,000 students in the department of mathematics reported that data collected during the first semester of utilization of computer applets in mathematics classes "indicated that students spent relatively little time, if any, exploring underlying mathematical concepts in these interactive environments. In other words, 'we built it, but they did not come.'" They stated that "the best designed instructional material, with the best available technology and best assessment instruments will be for naught in an asynchronous learning environment if the student does not utilize them or utilize them correctly!" Husch (2000) experienced similar results with the students in his calculus classes. Utilizing a program to track number of times a web page was accessed, Husch was able to determine that very few of the students accessed the Visual Calculus pages. Additionally, the calculus students reported that they did not utilize these pages.

There are many software programs in use, but perhaps they are not used in a manner that will meet the needs of all types of learners or are not designed with sound pedagogical theory. One author reported that his most important finding was that of the need to be more organized in his design. Kuntz (1996) stated that "the most significant oversight during the early stages of the project implementation was the need for a well-defined organization scheme for the materials."

With respect to the utilization of software tools, Arnold (1994) stated that

Software tools such as LOGO, Cabri Geometry, Theorist, SyMan, Derive, [Mathematica, Maple VI], and Calculus T/L II, among others, exemplify the most positive features of computer technology as a medium for learning:

- They place the user firmly in control of the technology;
- They encourage and reward exploration and inquiry;
- They offer capabilities impossible without the use of technology, and
- They are naturally mathematical: the user is immersed in mathematical concepts and actions, and is likely to take away from the encounter deep and versatile mathematical understandings.

Summary

The fact is that one in two students in most post-secondary first semester calculus classes will make a grade of D, F, or W (withdraw). There is an attempt to change this fact by many mathematics instructors. There exists many reports on learning styles and calculus, personality types and calculus, and technology and calculus; however, most are anecdotal. Many studies have not been statistically rigorous, nor have they involved the utilization of computers in an experimental design to show improvement. Most mathematicians are not versed in the nuances of instructional design, brain research, learning styles, or the like; therefore, the initial reports may be flawed in one or more ways. The expectation is that future studies will improve as experimenters in the fields of mathematics and mathematics education become more versed in the areas of educational technology, instructional design, and design of experiments. Experience has shown that merely putting class notes on the internet, is not utilizing the capabilities of the medium.

Arnold (1994) referred to a "'culture of mathematics learning' which serves as a significant impediment to the effective use of technology for mathematics learning." The success of technology utilization must be a shared responsibility, for as Gordon (1979) so aptly stated:

> In any realistic assessment of today's society and prospects for the future, it is clear that our lives are going to be increasingly affected by computers. This is especially true of the mathematics community. It is essential to emphasize applications in our courses. In particular, it is becoming increasingly important to incorporate computers into as many of our courses as possible. This must be done not merely as an educational aid but, more important, as a mathematical tool that is needed to solve the real-world problems that our students will one day face (as opposed to the relatively simple and artificial classroom problems usually presented). Not to do this is to do our students a disservice (Gordon, 1979).

Chapter III

METHODOLOGY

Introduction

The twofold goal of this research was 1) to understand why forty percent to fifty percent of the students in calculus classes at the University of Tennessee make less than a "C" in the first semester of calculus, and 2) to ascertain why the students do not utilize the web-based calculus tutorial, Visual Calculus, in order to improve their understanding of calculus. The original assumption was that individual learning styles, personality temperaments, and/or mathematics self-efficacy were major contributing factors to this situation.

The study answered the following research questions concerning the introductory calculus classes at the University of Tennessee, Knoxville:

1. How does student achievement vary with learning style preferences?
2. How does student achievement vary with temperaments?
3. How does student achievement vary with mathematics self-efficacy?
4. How does student achievement vary with teaching method?

Participants in the Study

This research study began with two sections of the introductory calculus class, Mathematics 141 Calculus I, during fall semester, 1999, at the University of Tennessee, Knoxville. Calculus I is the first semester course of a two-year, four-semester series designed by the mathematics department to meet the mathematics requirement for students majoring in the fields of science, engineering, mathematics, and computer science. The course covers differential and integral calculus with engineering applications. The pre-requisites for the course include three and one-half years of high school mathematics and a satisfactory score on the mathematics department's placement examination or successful completion of a collegiate pre-calculus course. The high school mathematics requirements include two years of algebra, one year of geometry, and one-half year of trigonometry.

Calculus I is a four-hour class. Approximately 20 sections of 35 students enroll in Calculus I fall semester of each school year. Students arbitrarily register for a section of the class that meets their respective schedules. Assignment to the class utilizing the web-based materials that met in the computer laboratory was purely arbitrary, in that no student knew, prior to the first day of class, which section would be taught by the professor utilizing the web-based calculus tutorial.

The section of the calculus class using the Visual Calculus web-based tutorial had 32 members, 21 of whom agreed to participate in the study; however only 13 students completed all inventories and the calculus achievement test. Each of the two sections of

Table 4

Mathematics 141 Students by Gender

Fall, 1999

Gender\Class	Calculus I Visual Calculus Number(Percentage)	Calculus I Lecture/Recitation Number(Percentage)	Total by Gender Number(Percentage)
Female	14 (44%)	15 (44%)	29 (44%)
Male	18 (56%)	19 (56%)	37 (56%)

Mathematics 141 Calculus I class had 44% females. For a breakdown of both sections of this class by gender, see Table 4.

The sample of students from the class that utilized Visual Calculus had 11 (52%) female students and 10 (48%) male students. Thirteen (62%) of the students had some form of calculus in high school. The majority of the students were freshman. For the breakdown by college class see Table 5.

Table 5

Classification of the Sample of Students Enrolled in Calculus I

Utilizing Visual Calculus

Fall, 1999

Student Classification	Number (Percentage)
Freshman	16 (76%)
Sophomore	2 (10%)
Junior	2 (10%)
Senior	1 (4%)

Table 6

Classification of the Sample of Students Enrolled in Calculus I

Lecture/Recitation Section

Fall, 1999

Student Classification	Number (Percentage)
Freshman	8 (62%)
Sophomore	4 (31%)
Junior	1 (7%)
Senior	0 (0%)

In the section of the Calculus I class taught by the traditional lecture/recitation method, 13 volunteered to participate in the study. Six students had previously taken calculus in high school. The sample contained six (46%) males and seven (54%) females. The majority of the students in this class were also freshmen. For the classification of this sample of students in the lecture/recitation class see Table 6.

The students in these classes declared majors in a variety of areas, some outside of the fields for which the course was designed. For the listing of majors for each of the classes see Table 7.

Due to the small number of students (13 for each section) who actually completed all inventories for the study, the researcher made the decision to extend the study to include the second semester calculus class, Mathematics 142 Calculus II, in the series. Each professor from the first semester taught a section of the Mathematics 142 class at the same time period during spring, 2000. The Mathematics 142 classes provided 29 additional students who completed all forms. See Table 8 for a breakdown by gender of

Table 7

Declared Majors of Calculus I Students

Fall, 1999

Major	**Calculus I (Visual Calculus) Number (Percentage)**	**Calculus I (Lecture) Number (Percentage)**
Statistics	1 (5%)	
Pre-Medicine/Pre-Pharmacy	2 (10%)	1 (8%)
Special Education	1 (5%)	
Biology	2 (10%)	4 ((31%)
Computer Science	5 (24%)	
Engineering	6 (29%)	3 (23%)
Environmental Studies	1 (5%)	
Accounting	1 (5%)	
Advertising		1 (8%)
Undecided	2 (10%)	4 (31%)

Note: Total Percentages may be greater than 100 due to rounding.

Table 8

Mathematics 142 Students by Gender

Spring, 2000

Gender\Class	Calculus II Visual Calculus Number(Percentage)	Calculus II Lecture/Recitation Number(Percentage)	Total by Gender Number(Percentage)
Female	11 (31%)	9 (26%)	20 (29%)
Male	24 (69%)	26 (74%)	50 (71%)

mathematics 142 students who participated in the study. Notice the decrease in the percentage of females from the first semester calculus class in which approximately 44% of the students were female. The total number of females for the two Calculus II classes was approximately 29%, a 15% decline from the first semester class. A larger percentage of students enrolled in Mathematics 142 Calculus II chose majors in engineering, the sciences, or mathematics. See Table 9.

Instructors

For both semesters, each section was taught by a full-professor with more than 30 years of teaching experience. For each semester, only one of the Calculus I and one of the Calculus II sections utilized Visual Calculus; therefore, the researcher was limited to those two sections for the study. The two sections of lecture/recitation section were chosen for the following reasons:

1. Both sections of calculus I and II were scheduled for the noon hour, and

Table 9

Mathematics 142 Students by College Major

Spring, 2000

College Major	Calculus 142 Visual Calculus	Calculus 142 Lecture
Engineering	7	16
Science, mathematics	11	8
Fine Arts	3	1
Agriculture	4	2
Education	1	
Communications	2	1
Architecture		2
G		1
Undecided	4	3

2. Both professors had equivalent teacher ratings by former students, equivalent rankings within the mathematics department, and approximately the same number of years of teaching experience.

Course

As stated previously, Mathematics 141 Calculus I is the first course of a two-year series of calculus offered in the mathematics department at the University of Tennessee, Knoxville. Mathematics 142 Calculus II is the second semester in this series. All semesters are four-hour courses meeting Monday-Wednesday-Friday and either Tuesday or Thursday for 50 minutes for 15 weeks. The enrollment for each section is limited to 35 students, and during the fall of each school year there are approximately 20 sections of Mathematics 141 taught. The majority of these sections are taught by the lecture/recitation method and most sections require the use of graphing calculators of the students' choice; although, a few professors do not allow calculators in their classes. Some instructors encourage the use of computers for exploration and concept understanding. The professors for both sections under study required graphing calculators for some homework and test problems. All sections of the two-year series of calculus used the textbook, Calculus: Concepts and Context, by Stewart (1995).

Visual Calculus

In the sections of Calculus I and II that used the Visual Calculus web-based tutorials, the students met in a computer laboratory each class period. The professor for those sections designed the web-based tutorials to accompany the topics covered in the calculus classes. The lecture notes and demonstrations were online, and the students had the option to follow along on their computer monitor as the lecture and demonstrations took place and listen or to take notes as usual. Students could sign onto the internet after the class periods and use the Visual Calculus to do one or all of the following.

1. Review the lecture notes for the day.
2. Review randomly generated sample problems complete with step-by-step solutions, and/or
3. Work through randomly generated problems then check their answers.

The web materials could be accessed from any computer having an internet connection. There are several computer laboratories on campus available for student use; therefore, computer and internet access were not considered to be a problem. Students were encouraged to utilize these materials to further their understanding of the topics and to learn to work the problems by studying and and/or working the randomly generated problems. Each problem has an interactive, step-by-step solution available to provide an opportunity for the students to practice working problems and to gain "hints" for areas of difficulty in completing the problems. The tutorials are designed to provide students with an opportunity to work problems and to check the steps in order to gain mastery of each topic. An online diary of the class lecture notes and homework was available for the students; therefore, any student who was absent from class could review the topics for any particular day.

Instruments

For the study, each class was administered three questionnaires/inventories and one calculus achievement test during their respective semesters of participation in the study. These instruments were the Myers-Briggs Type Indicator (MBTI), the Felder-Silverman Index of Learning Styles (ILS), and the Mathematics Self-Efficacy Scale (MSES). The final, hourly test in all four sections of calculus was a comprehensive test in which each successive topic in calculus necessitated the knowledge of prior topics. Six students volunteered to be interviewed in an attempt to gain insight into how the students use the tutorials in Visual Calculus and to receive suggestions for improvement to the tutorials.

Felder-Silverman Index of Learning Styles (ILS)

The Felder-Silverman Index of Learning Styles was formulated and tested by Felder, a chemical engineering professor at North Carolina State University, and Silverman, an educational psychologist at the University of Denver. The model was developed for applications with students in technical disciplines. The index contains 44 questions, 11 each for four dimensions of learning. These dimensions determine a person's preference for active vs. reflective, sensing vs. intuitive, visual vs. verbal, and sequential vs. global learning. The 44 questions are coupled with two responses in which the respondents chose the one answer which best fits their preferred mode of learning. The selection of answers for each set of 11 questions determines the preference within each dimension. The total of the “a” and “b” responses for each question associated with a given dimension are combined to give a total score for each dimension, much like the Myers-Briggs determination of the four dimensions of personality type. A copy of the Felder-Silverman ILS can be found in Appendix B.

Although Felder has previously established reliability of the ILS instrument, reliability was computed on the participant inventories utilizing Kuder-Richardson 20. Alphas ranged from .65 - .87 for the four dimensions of the Index of Learning Styles (ILS). Content validity was established by the authors, Felder and Silverman, during the development of the ILS index for technical students.

Mathematics Self-Efficacy Scale (MSES)

The Mathematics Self-Efficacy Scale is a 34-item questionnaire designed to measure persons’ beliefs regarding their ability to perform certain mathematics related tasks and behaviors. The results may be used in research or counseling interventions. The first 18 items are related to people’s perceptions of their ability to successfully complete everyday mathematics tasks such as balancing a checkbook or determining the amount of sales tax on a clothing purchase. These items are related to students’ mathematics anxiety. Some of the items are adapted from the Math Anxiety Rating Scale developed by Goldman and Hewitt (Betz & Hackett, 1993). The last 16 items are related to students' confidence to attain a grade of "A" in college courses requiring mathematics. The content areas are arithmetic, algebra, and geometry and span three types of operations, namely, comprehension, computational skill, and applications of mathematics principles in both the real and abstract arena. The items are rated on a scale of 0-9 with 0 being "no confidence at all" and 9 being "complete confidence." A score and average is obtained for each section and an overall score and average for the total instrument. A copy of the MSES can be found in Appendix C.

Reitman (Betz and Hackett, 1993) established the reliability of a revised MSES used in grade school with coefficient alphas for the two sub-scales of Mathematics Tasks and Mathematics Problems of .87 and .91, respectively. According to Betz and Hackett (1993), content validity was established in the development of the MSES by "detailed and comprehensive specification of the domain of interest" (Betz and Hackett, 1993).

Myers-Briggs Type Indicator (MBTI)

The MBTI measures personality types as defined by Jungian theory. There are several published forms; however this study utilized Form G, the most widely used form. The instrument contains 126 items – 81 questions ask about how the respondent feels or prefers to act in certain situations and 45 word pairs in which the respondent chooses the word that is most appealing. The questions refer to situations, such as whether a person would prefer to "be introduced" or to "introduce themselves" at a party. The word pairs contain words such as "calm" and "lively". The respondent reads the questions and word pairs and is instructed to choose an “a” or “b” answer which best describes how he/she would act or feel and to choose an “a” or “b” answer for each word pair.

Each item determines a person’s preference for one of the four bipolar dimensions. The respondents mark their answers on scantron forms that can be scanned by an optical scanner or hand-scored with templates. Due to the small number of participants in this study, the forms were hand-scored. The objective of the instrument is to determine the four preferences in each dimension for each respondent. When the MBTI is scored, a person is categorized as either an E (extrovert) or I (introvert), an S (sensor) or N (intuitive), a T (thinker) or F (feeler), and a J (judger) or P (perceiver) resulting in one of 16 personality types -- ESTJ, ESFJ, ENFJ, ENTJ, ESTP, ESFP, ENFP, ENTP, ISTP, ISFP, INFP, INTP, INTJ, INFJ, ISFJ, or ISTJ. The personality types will then determine the temperaments of NF, NT, SJ, or SP.

The MBTI has been tested for its validity and reliability. Curry (1983) reviewed 21 models of learning style and concluded that the MBTI was acceptable for psychometric use. According to Curry (1990), the internal split-half reliability was reported in the .80 - .86 range and test-retest reliability in the .70 - .83 range. Internal reliability, estimated by the coefficient alpha and corrected by the Spearman-Brown prophecy formula, yielded an .82 for E versus I, an .81 for S versus N, an .82 for T versus F, and an .86 for J versus P preferences (Myers and McCaulley, 1985).

Calculus Achievement Test

Calculus achievement was determined by the score on the fourth, hourly test given to the students in each of the classes. A copy of the tests for both Mathematics 141

Calculus I and Mathematics 142 Calculus II can be found in Appendices D and E, respectively. The test for the Mathematics 141 classes was designed by the professors involved in the study to measure students' achievement over the topics covered in the last 25% or approximately 3 weeks of the classes. All students received grades in the calculus series based on four hourly exams, homework, and a final comprehensive 90-minute exam. For the purposes of this study, the classes for both semesters were administered identical questions on the fourth, hourly exam. A partial credit scheme was developed and all tests for all classes were scored based on the partial credit scheme. Reliability for the two calculus tests was computed by Kuder-Richardson 20 with alphas of .85 and .87, respectively. To establish the validity of the calculus achievement exam, two senior mathematics professors who teach the calculus series in the mathematics department at the University of Tennessee, Knoxville were asked to compare the test items to the objectives of the course material and determine the content validity for the test. Both mathematics professors concurred that the test was valid for the stated objectives. The course syllabus can be found in Appendix F.

Data Collection

Data were collected for this study from several sources. Approximately one month after classes began in both the fall, 1999, and the spring, 2000, the calculus students completed the Felder-Silverman Index of Learning Style (ILS), the Mathematics Self-Efficacy Scale (MSES), and the Myers-Briggs Type Indicator (MBTI). The students completed these instruments outside of class. In all calculus classes both semesters, the calculus achievement test was given to the students approximately one week before the end of the semester. Mathematics ACT scores were provided by the university Records Office.

Data Analysis

The primary statistical procedures used in this study were descriptive statistics--Kuder-Richardson 20 test of reliability, correlational analysis, and analysis of variance, including post hoc Scheffe and Duncan multiple comparison tests to identity specific significant means, where appropriate. The significance level of 0.05 was used in all hypothesis tests with appropriate p-values reported.

Summary

In summary, this study involved participants from four calculus classes, two Calculus I and two Calculus II classes, during the school year 1999-2000, at the University of Tennessee, Knoxville. Three inventories, ILS, MSES, and MBTI, were administered near the beginning of each semester and the fourth, hourly calculus achievement test was given near the end of each semester. Data were gathered from the university, the students, and the professors for each of the four classes. The data were collated and analyzed using SAS 8.0 for PC. The primary procedures were descriptive statistics, tests of reliability, tests of correlation, and comprehensive analysis of variance with appropriate post hoc multiple comparison tests which are reported in Chapter IV: Results.

Chapter IV

RESULTS

Introduction

The primary purpose of this study was to determine the relationship between learning style preferences, personality temperament types, and mathematics self-efficacy on the achievement and course completion rate of a sample of the University of Tennessee at Knoxville college students enrolled in first and second semester calculus classes which utilized web-based materials. To collect the data, four instruments were used. These include the Myers Briggs Type Indicator (MBTI), The Felder-Silverman Index of Learning Styles (ILS), the Mathematics Self-Efficacy Scale (MSES), and the end of semester calculus tests. In addition, six students volunteered to be interviewed. These interviews were transcribed and analyzed to obtain information pertaining to the improvement of the Visual Calculus web site.

The primary statistical procedures used to test the hypotheses of this study were descriptive statistics, analysis of variance (ANOVA), correlational analyses, and Kuder Richardson 20 reliability analyses. The primary hypotheses of this study were tested for significance by using three-way analyses of variance. Duncan’s Multiple Range Test for pair-wise means comparisons were applied, where appropriate. Pearson product moment correlation coefficients were computed for ACT mathematics scores, MSES - Part I, MSES - Part II, MSES - Total, and the calculus tests. For this study, the statistically significant results for each hypothesis are presented with discussion, tables, and figures; however those results that were not found to be statistically significant are summarized and the descriptive statistics and analysis of variance summary results are located in the appropriate appendix.

Hypotheses

The six null hypotheses of this study were rejected or not rejected based on the results of three-way analyses of variance. The level of significance utilized for all statistical tests was $\alpha = 0.05$. The following are the results for each null hypothesis.

Learning Styles and ACT Mathematics Scores

H_0: There are no significant differences in the mean ACT mathematics scores for the first and second semester calculus students with respect to the four learning styles. This hypothesis was tested using four three-way ANOVA models (Semester by Teaching Method by Learning Style Dimension). The four models are:

1. Semester by Teaching Method by Dimension 1 (active vs. reflective),
2. Semester by Teaching Method by Dimension 2 (intuitive vs. sensing),
3. Semester by Teaching Method by Dimension 3 (visual vs. verbal), and
4. Semester by Teaching Method by Dimension 4 (global vs. sequential).

The mean and standard deviation for the ACT mathematics score for the total group, n = 62, was 19.3 and 7.32, respectively, and the scores ranged from a low of 12 to a high of 32. Fifty-six students with ACT mathematics scores in their records answered the ILS. For each dimension, a person was rated as one of the alternatives. For instance, a person could be a reflective learner for Dimension 1, an intuitive learner for Dimension 2, a visual learner for Dimension 3, and a global learner for Dimension 4. For a breakdown of the percentages of the total number of student participants by learning style dimension alternatives see Table 10.

Note that Dimension 3 and Dimension 4 have one of the alternatives more likely to occur. There are approximately seven times more visual learners than verbal learners and approximately twice as many sequential learners as there are global learners. These proportions were tested for significance and found to be significantly different at a $p = 0.0$ and a $p = 0.0002$ level of significance, respectively.

Each dimension of the learning style was analyzed separately with respect to the dependent variables, ACT mathematics scores, calculus test, MSES - Part I, MSES - Part II, and MSES - Total; therefore, the two semesters by two teaching methods per semester by four dimensions (eight alternatives) yielded a total of 32 groups. Within these 32 groups the ACT mathematics score means ranged from a low of 12.0 to a high of 28.0 and the standard deviations ranged from 0 to 10.63. For the means, standard deviations, and sample size for each alternative of each dimension refer to Appendix G.

Table 10

Classification of All Calculus Student Participants

With Respect to Learning Style Dimension

Fall, 1999 – Spring, 2000

Dimension of Learning Style	First Alternative of Learning Style Dimension Number (Percentage)	Second Alternative of Learning Style Dimension Number (Percentage)
1	Active 30 (54.6%)	Reflective 25 (45.4%)
2	Intuitive 25 (45.4%)	Sensing 30 (54.6%)
3	Visual 48 (87.3%)	Verbal 7 (12.7%)
4	Global 19 (34.6%)	Sequential 36 (65.4%)

The four three-way analyses of variance models, one for each dimension of learning style and ACT mathematics score as the dependent variable, resulted in no statistically significant differences. The resulting p-values ranged from a low of 0.16 to a high of 0.93; therefore, the null hypothesis which stated that there are no differences in mean mathematics ACT scores for learning style was not rejected at the $\alpha = 0.05$ significance level, and ACT mathematics scores were not used as a covariate in any of the subsequent analyses concerning learning style dimensions. See Table 11 for a summary of the p-values for the ANOVA results for these four analyses. The specific ANOVA summary tables for each model are found in Appendix H.

Table 11

P-Values for ANOVA Results

Dependent Variable: Mathematics ACT Scores

Model: Semester by Teaching Method by Learning Style Dimension

ANOVA Summary Table Source of Variability	P-values Dimension of Learning Style			
	1	2	3	4
Semester	0.93	0.93	0.92	0.93
Teaching Method	0.69	0.68	0.68	0.69
Learning Style	0.83	0.48	0.16	0.80

Learning Style and Calculus Test

H_0: There are no significant differences in the mean calculus test grades for first and second semester calculus students with respect to the four learning styles. This hypothesis was tested using four three-way ANOVA models (Semester by Teaching Method by Learning Style). The four models are:

1. Semester by Teaching Method by Dimension 1 (active vs. reflective),
2. Semester by Teaching Method by Dimension 2 (intuitive vs. sensing),
3. Semester by Teaching Method by Dimension 3 (visual vs. verbal), and
4. Semester by Teaching Method by Dimension 4 (global vs. sequential).

Table 12

Mean, (Standard Deviation), and n for Calculus Test Scores

Dimension 1 Learning Style Preference

Active vs. Reflective Learners

Dimension 1 Row Mean N	Semester 1		Semester 2	
	Teaching Method		Teaching Method	
	A	B	A	B
Active 66.67 32	78.3 (14.77) 5	77.4 (15.69) 12	48.6 (33.66) 7	59.2 (19.50) 8
Reflective 83.40 29	82.4 (31.85) 9	88.3 (9.43) 4	87.2 (10.63) 6	79.2 (19.00) 8

A: Lecture/Recitation Calculus

B: Web-based Calculus

For Dimension 1: Active vs. Reflective learners, a total of 56 students completed the ILS and took the calculus test; therefore, the ANOVA was based on 56 observations. For this dimension, calculus test scores ranged from 0 to 100 and mean test scores ranged from a low of 48.6 to a high of 89.0 with standard deviations ranging from a low of 9.43 to a high of 33.66. The first and second semester calculus means were 80.5 and 67.9, respectively. For a complete breakdown of the means by each group within the four classes, see Table 12.

Analysis of variance completed for Dimension 1 resulted in statistically significant findings. The class variables of Semester and Dimension were significantly

Table 13

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 1: Active vs. Reflective

Dependent Variable: Calculus Test					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	2329.51	1	2329.52	4.79	0.03
Between Treatments	12.33	1	12.33	0.03	0.87
Between Levels	4660.24	1	4660.24	9.58	0.003
Error	26743.01	55	486.24		
Total	33745.10	58			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

different with p = 0.03 and p = 0.003 levels of significance, respectively. For a summary of the ANOVA results, see Table 13.

Although the semester calculus test means were significantly different at p = 0.03 for Calculus 141 and Calculus 142 test means of 80.5 and 68.0, respectively, the results of interest were the within semester calculus test means and the individual Dimension 1 group calculus test means. Duncan’s Multiple Range Tests for pair-wise means comparisons for Teaching Method revealed no significant differences in calculus test mean scores for either Teaching Method for the overall means of 74.6 and 74.0; however, Dimension 1: Active (Act) vs. Reflective (Ref) Learner Mean Calculus Test Scores

Ref	Ref	Ref	Ref	Act	Act	Act	Act
88.3	87.2	82.4	79.2	78.3	77.4	59.2	48.6

Note: Those means superscripted by a continuous line segment are not significantly different.

Figure 1. Results of post hoc Duncan's Multiple Range Test for calculus test scores with respect to Dimension 1 learning style.

means for Dimension 1 learners in the two calculus classes were significantly different with the reflective learner mean of 83.4 and the active learner mean of 66.7.

Comparisons by semester resulted in no significant difference for Calculus 141; however the Calculus 142 test means were significantly different at 82.6 for reflective learners and 54.2 for active learners. Therefore, the null hypothesis of no significant difference in mean calculus grades with respect to Dimension 1 learning style was rejected.

For a comparison of all eight Dimension 1 learner groups, Duncan's Multiple Range Test found the active learner, lecture/recitation, Calculus 142 group with calculus test mean of 48.6 significantly different than six of the other Dimension 1 alternative groups (see Figure 1).

Table 14

Mean, (Standard Deviation), and n for Calculus Test Scores

Dimension 2 Learning Style Preference

Intuitive vs. Sensing Learners

Dimension 1 Row Mean N	Semester			
	1		2	
	Teaching Method		Teaching Method	
	A	B	A	B
Intuitive	76.1 (13.88) 3	77.9 (16.06) 3	49.2 (37.70) 4	73.3 (16.90) 8
Sensing	82.3 (29.27) 11	85.0 (12.08) 5	74.1 (30.13) 9	65.0 (25.39) 8

A: Lecture/Recitation Calculus

B: Web-based Calculus

For Dimension 2: Intuitive vs. Sensing learners, a total of 59 students completed the ILS and took the calculus test; therefore, the ANOVA was based on 59 observations. For this dimension, calculus test scores ranged from 0 to 100 and mean test scores ranged from a low of 49.2 to a high of 85.0 with standard deviations ranging from a low of 12.08 to a high of 37.70. The first and second semester calculus means were 80.5 and 67.9, respectively. For a complete breakdown of the means by each group within the four classes, see Table 14

Analysis of variance for the model, Semester by Teaching Method by Dimension 2: Intuitive vs. Sensing learners with calculus test as the dependent variable, resulted in

Table 15

ANOVA Summary Table

Semester By Instructor By Learning Style Dimension

Dimension 2: Intuitive vs. Sensing

Dependent Variable: Calculus Test					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	2329.52	1	2329.52	4.14	0.05
Between Treatments	12.33	1	12.33	0.02	0.88
Between Levels	477.61	1	477.61	0.85	0.36
Error	30925.65	55	562.28		
Total	33745.10	58			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

statistically significant differences in the semester class variable. For analysis of variance summary results see Table 15.

Duncan's Multiple Range Tests for pair-wise comparisons for semester resulted in the same finding as in Dimension 1 that the semester means were significantly different at 80.5 and 67.9 for Calculus 141 and 142, respectively. Pair-wise comparisons for intuitive and sensing learners within the four classes resulted in no significant differences for calculus test means with respect to intuitive and sensing learners; however, pair-wise comparisons of the eight individual groups found significant differences at the $\alpha = 0.05$ level of significance (see Figure 2). Therefore, we reject the null hypothesis and

Dimension 2: Intuitive (N) vs. Sensing (S) Learner Mean Calculus Test Scores

S	S	N	N	S	N	S	N
85.0	82.3	77.9	76.1	74.1	73.3	65.0	49.2

Note: Those means superscripted by a continuous line segment are not significantly different.

Figure 2. Results of post hoc Duncan's Multiple Range Test for calculus test scores with respect to Dimension 2 learning style. (Note that the analysis means may vary from the total group means.)

conclude that there exist significant differences with respect to Dimension 2 alternative learning styles.

In Dimension 3: Visual vs. Verbal learners and Dimension 4: Global vs. Sequential learners, a total of 59 students completed the ILS and took the calculus test; therefore, the ANOVAs were based on 59 observations. For these dimensions, individual calculus test scores ranged from 0 to 100 and group test score means ranged from a low of 64.7 to a high of 89.0 and a low of 51.1 to a high of 88.0, respectively. The class variable, Semester, was found to be significant; however, this is not additional information for these models and does not apply to the class variables of interest. For a complete breakdown of the means by each group within the four classes and the analysis of variance results, see Appendix G and Appendix I.

Learning Style and MSES – Part I

H_0: There are no significant differences in the mean Mathematics Self-Efficacy Scale (MSES) – Part I scores for first and second semester calculus students with respect to the four learning styles. This hypothesis was tested using four three-way ANOVA models. (Semester by Teaching Method by Learning Style). The four models are:

1. Semester by Teaching Method by Dimension 1 (active vs. reflective),
2. Semester by Teaching Method by Dimension 2 (intuitive vs. sensing),
3. Semester by Teaching Method by Dimension 3 (visual vs. verbal), and
4. Semester by Teaching Method by Dimension 4 (global vs. sequential).

Analyses of variance were completed for MSES - Part I, MSES – Part II, and MSES – Total with respect to learning style dimensions for a total of twelve models, four for each dependent variable. There were several statistically significant findings with respect to a dimension of learning style and the MSES scores. Only those models producing statistically significant results will be discussed in detail. A summary of the p-values for each class variable is reported in Table 16. The ANOVA summary tables for models without significant results for MSES – Part I can be found in Appendix J.

For the model, Semester by Teaching Method by Dimension 3: Visual vs. Verbal learners and dependent variable, MSES – Part I, the mean scores were significantly different for the class variable, Learning Style (see Table 16). Although the Dimension 3 mean scores for MSES – Part I were significantly different, the mean for the visual

Table 16

P-Values for ANOVA Results

Dependent Variable: Mathematics Self-Efficacy Scale – Part I

Model: Semester by Teaching Method by Learning Style Dimension

ANOVA Summary Table Source of Variability	P-values Dimension of Learning Style * Denotes a Significant Finding			
	1	2	3	4
Semester	0.13	0.14	0.12	0.13
Teaching Method	0.95	0.95	0.95	0.95
Learning Style	0.63	40.42	0.04*	0.22

group was 7.34 and the verbal group was 6.86, both of which are contained in the "Much Confidence" category of the MSES; therefore a significant difference for the semester means does not appear to be a practical difference.

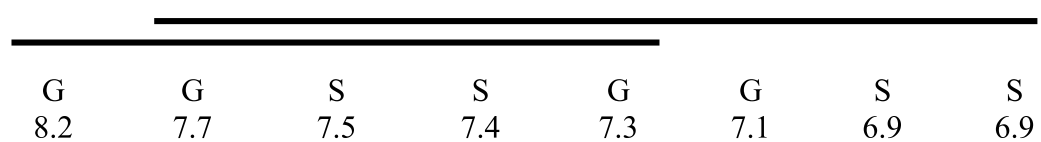
The means for visual and verbal learners were tested for differences in the case of classes, teaching method, individual groups by semester, and individual groups, where appropriate, resulting in no significant differences. There was one verbal learner in the Calculus 142 classes; therefore, no analyses were possible for second semester classes. Although Dimension 4: Global vs. Sequential learning styles did not produce a significant result at the $\alpha = 0.05$ level of significance, a post hoc Duncan's Multiple Range Test resulted in a significant finding for the Calculus 142 classes (see Figure 3). For the eight groups of Dimension 4, see Figure 4.

Dimension 4: Global (G) vs. Sequential (S) Learner Mean MSES – Part I Calculus 142 semester mean scores

Note: Those means superscripted by a continuous line segment are not significantly different.

Figure 3. Results of post hoc Duncan's Multiple Range Test for MSES – Part I scores with respect to Dimension 4 learning style.

Dimension 4: Global (G) vs. Sequential (S) Learner Mean MSES – Part I Calculus 142 mean scores



Note: Those means superscripted by a continuous line segment are not significantly different.

Figure 4. Results of post hoc Duncan's Multiple Range Test for MSES – Part I scores with respect to Dimension 4 learning style.

Table 17

P-Values for ANOVA Results

Dependent Variable: Mathematics Self-Efficacy Scale – Part II

Model: Semester by Teaching Method by Learning Style Dimension

ANOVA Summary Table Source of Variability	P-values Dimension of Learning Style			
	1	2	3	4
Semester	0.15	0.14	0.14	0.14
Teaching Method	0.19	0.19	0.19	0.17
Learning Style	0.58	0.32	0.36	0.06

A mean score of 8.2 is significantly higher than the mean of 6.9 in that a score of eight or nine falls in the "Complete Confidence" category.

Learning Style and MSES – Part II

In like manner, the four models for dimensions of learning style were computed for mean MSES – Part II scores. No model produced a significant result at the $\alpha = 0.05$ level of significance. One model produced a statistically significant result at the $p = 0.06$ level; however the semester mean MSES – Part II scores for global learners and sequential learners were 6.34 and 6.92, respectively. These scores do not have practical difference for the mean MSES – Part II scores. For a summary of the p-values for these four ANOVA models, see Table 17.

Learning Style and MSES – Total

The four three-way analysis of variance models for dimension of learning style were computed for mean MSES – Total scores. All models produced a statistically significant result at the p = 0.05 level for the class variable semester. For Dimension 3: Visual vs. Verbal learners, the second semester of calculus had one verbal learner versus 27 visual learners. With a sample of size one in one of the four groups, the results should be scrutinized. The mean MSES – Total scores for all of the groups in this dimension ranged from a low of 6.37 to a high of 7.84. For a summary of the means, standard deviations, and sample sizes – n for these groups, see Tables 18, 19, 20, and 21.

Table 18

Mean Mathematics Self-Efficacy – Total Scores

Mean, (Standard Deviation), n

Dimension 1 Learning Style: Active vs. Reflective Learners

Dimension 1 Row Mean n	Semester 1		Semester 2	
	Teaching Method		Teaching Method	
	A	B	A	B
Active 7.02 29	7.16 (1.04) 5	7.31 (0.57) 10	7.19 (0.62) 6	6.46 (0.97) 8
Reflective 7.09 27	7.10 (1.15) 9	7.03 (0.29) 4	7.02 (0.64) 6	6.77 (0.94) 8

A: Lecture/Recitation Calculus

B: Web-based Calculus

Table 19

Mean Mathematics Self-Efficacy – Total Scores

Mean, (Standard Deviation), n

Dimension 2 Learning Style: Intuitive vs. Sensing Learners

Dimension 2 Row Mean n	Semester			
	1		2	
	Teaching Method		Teaching Method	
	A	B	A	B
Intuitive 6.99 24	7.10 (1.30) 3	7.21 (0.57) 9	7.30 (0.72) 4	6.53 (0.75) 8
Sensing 7.11 32	7.43 (1.08) 11	7.27 (0.43) 5	7.01 (0.57) 8	6.69 (1.15) 8

A: Lecture/Recitation Calculus

B: Web-based Calculus

Table 20

Mean Mathematics Self-Efficacy – Total Scores

Mean, (Standard Deviation), n

Dimension 3 Learning Style: Visual vs. Verbal

Dimension 3 Row Mean n	Semester 1		2	
	Teaching Method		Teaching Method	
	A	B	A	B
Visual 7.10 48	7.54 (1.01) 11	7.32 (0.56) 10	7.17 (0.60) 11	6.61 (0.94) 16
Verbal 6.81 8	6.70 (1.29) 3	7.00 (0.28) 4	6.4 -- 1	-- -- 0

A: Lecture/Recitation Calculus

B: Web-based Calculus

Table 21

Mean Mathematics Self-Efficacy – Total Scores

Mean, (Standard Deviation), n

Dimension 4 Learning Style: Global vs. Sequential

Dimension 4 Row Mean n	Semester 1		Semester 2	
	Teaching Method		Teaching Method	
	A	B	A	B
Global 7.39 19	7.21 (1.67) 5	7.50 (0.45) 6	7.84 (0.30) 3	7.15 (0.63) 5
Sequential 6.89 37	7.45 (0.70) 9	7.02 (0.47) 8	6.86 (0.46) 9	6.37 (0.98) 11

A: Lecture/Recitation Calculus

B: Web-based Calculus

P-values for the class variable, semester, were less than the $\alpha = 0.05$ level of significance; however, the large concentration of visual learners in the second semester of calculus could have a significant impact in these analyses for Dimension 3. For a summary of the p-values for these four models, see Table 22.

Duncan's Multiple Range Test on pair-wise comparisons resulted in the means for global learners being significantly different than sequential learners at 7.4 and 6.9, respectively; however both of these means lie in the "Much Confidence" category. Significant differences were found for semester means, class means in Calculus 142 classes, and individual group means; however, the means ranged from a low of 6.4 to a high of 7.8, the "Much Confidence" category.

Table 22

P-Values for ANOVA Results

Dependent Variable: Mathematics Self-Efficacy Scale – Total

Model: Semester by Teaching Method by Learning Style Dimension

ANOVA Summary Table Source of Variability	P-values Dimension of Learning Style *Denotes a Significant Finding			
	1	2	3	4
Semester	0.04*	0.04*	0.04*	0.04*
Teaching Method	0.17	0.17	0.16	0.17
Learning Style	0.87	0.87	0.10	0.87

In summary, there were several significant differences with respect to learning style dimensions and Mathematics Self-Efficacy Scale (MSES) scores; however, these significant results are questionable as to their practicality.

Temperament ACT Mathematics Scores

H_0: There will be no significant difference in the mean ACT mathematics scores for first and second semester calculus students with respect to temperaments. This hypothesis will be tested using a three-way ANOVA. (Semester by Teaching Method by Temperament)

Sixteen respondents from each of the two Calculus 141 classes, 10 respondents from the lecture/recitation Calculus 142 class, and 17 students from the web-based Calculus 142 classes for a total of 55 students answered the MBTI. For a total

Table 23

Classification of All Calculus Student Participants

With Respect to Temperaments

Fall, 1999 – Spring, 2000

Temperament	Number (Percentage)
NF Idealist	20 (36.4%)
NT Rational	12 (21.8%)
SJ Guardian	20 (36.4%)
SP Artisan	3 (5.5%)

Note: Percentages may not sum to 100, due to rounding errors.

breakdown of percentage of student participants by temperament for each class that participated in the study, see Table 23.

Note the small percentage of SP temperaments. There were three students, or less than six percent, of the 55 who responded to the MBTI categorized as the SP temperament. Within the 16 groups of students for the model, Semester by Teaching Method by Temperament, the mean ACT mathematics scores ranged from a low of 12 to a high of 23.7 with standard deviations ranging from a low of 0 to a high of 9.38. For the descriptive statistics for these four temperament groups, see Appendix K.

Table 24

ANOVA Summary Table

Semester By Teaching Method By Temperament

Dependent Variable: Mathematics ACT Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	21.14	1	21.14	0.36	0.55
Between Treatments	17.30	1	17.30	0.30	0.59
Between Levels	45.59	3	15.20	0.26	0.85
Error	2848.16	51	58.13		
Total	2932.18	54			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

A three-way analysis of variance was performed with Semester, Teaching Method, and Temperament as class variables and ACT mathematics scores as the dependent variable. There were no statistically significant differences at the $\alpha = 0.05$ level of significance with p-values ranging from 0.55 to 0.85. Therefore, the null hypothesis of mean ACT mathematics scores being equal for temperament groups was not rejected, and ACT mathematics scores were not used as a covariate in any analyses concerning temperaments. For the ANOVA summary table see Table 24.

Temperament and Calculus Test

H_0: There are no significant differences in the mean calculus test scores for first and second semester calculus students with respect to their temperaments. This hypothesis will be tested using a three-way ANOVA. (Semester by Teaching Method by Temperament)

Sixty students who completed the MBTI took the calculus tests for both Calculus 141 and Calculus 142. A three-way analysis of variance model, Semester by Teaching Method by Temperament and the dependent variable calculus test score, produced statistically significance results for the class variable temperament at the $p = 0.06$ level of significance. The means for these groups ranged from a low of 48.9 to a high of 83.0. For ANOVA summary table results, see Table 25.

A post hoc Duncan Multiple Range Test for calculus test scores with $\alpha = 0.05$ determined that the SP temperament, calculus mean score was significantly different than the three remaining temperament group scores. For the results of the Duncan Multiple Range Test, see Figure 5.

Temperament and MSES – Part I

H_0: There will be no significant difference in the mean calculus test scores for first and second semester calculus students with respect to their MSES – Part I scores. This hypothesis will be tested using a three-way ANOVA. (Semester by Teaching Method by Temperament)

Table 25

ANOVA Summary Table

Semester By Teaching Method By Temperament

Dependent Variable: Calculus Test Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Groups	453.90	1	453.90	1.09	0.30
Between Treatments	432.44	1	432.44	1.03	0.32
Between Levels	3236.44	3	1088.48	2.60	0.06
Error	22564.13	54	417.85		
Total	26715.93	59			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

MBTI Temperament Mean Calculus Test Scores

SJ	NF	NT	SP
89.3	76.4	71.3	48.9

(SJ, NF and NT are joined by a continuous line segment.)

Note: Those means superscripted by a continuous line segment are not significantly different.

Figure 5. Results of post hoc Duncan's Multiple Range Test for calculus test scores for temperament groups.

Table 26

ANOVA Summary Table

Semester by Teaching Method by Temperament

Dependent Variable: MSES – Part I Mean Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Groups	2.46	1	2.46	3.34	0.07
Between Treatments	0.09	1	0.09	0.12	0.73
Between Levels	0.50	3	0.17	0.23	0.88
Error	35.33	49	0.74		
Total	38.38	54			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

Fifty-four participants who filled out the MBTI also completed the MSES. The temperament group means ranged from a low of 6.9 to a high of 7.3. The three-way analysis of variance for the model, Semester by Teaching Method by Temperament with dependent variable MSES – Part I scores, produced p-values ranging from 0.07 to 0.87 and found the class variable semester to be significantly different at the $p = 0.07$ level of significance. For ANOVA summary table results, see Table 26.

Since there were no significant differences at the $\alpha = 0.05$ level of significance, a post hoc Duncan Multiple Range Test for MSES- Part I means was not appropriate;

however an investigation of the data resulted in locating one low score of 5.0 for the second semester SP group mean. There were only three SPs in the total sample and only one SP in the second semester. The statistical application program, SAS, would have considered this group of size one with the same weighting as any larger group; thus, calculating the $p = 0.07$ level of significance for semester.

MBTI Temperament and MSES – Part II

H_0: There are no significant differences in the mean MSES- Part II scores for first and second semester calculus students with respect to their temperaments. This hypothesis will be tested using a three-way ANOVA. (Semester by Teaching Method by Temperament)

Fifty-four students answered both the MSES – Part II and the MBTI. The temperament group means ranged from 5.33 to 6.88. The three-way analysis of variance for the model, Semester by Teaching Method by Temperament with MSES – Part II scores, produced p-values ranging from 0.10 to 0.17; therefore no class variable was significant at the $\alpha = 0.05$ level of significance. For ANOVA summary table results, see Table 27.

A Duncan's Multiple Range Test to compare temperament group differences for MSES – Part II did find significant differences at the $\alpha = 0.05$ level of significance. See Figure 6. Note that the SP group contains only three observations; however, the one SP in the lecture/recitation Calculus 142 class scored 3.4 on the MSES – Part II, and this

Table 27

ANOVA Summary Table

Semester by Teaching Method by Temperament

Dependent Variable: MSES – Part II Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Groups	2.08	1	2.08	1.98	0.17
Between Treatments	2.34	1	2.34	2.22	0.14
Between Levels	6.94	3	2.31	2.20	0.10
Error	50.57	48	1.05		
Total	61.94	53			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

MBTI Temperament Mean MSES – Part II Scores

SJ	NT	NF	SP
6.9	6.5	6.4	5.3

Note: Those means superscripted by a continuous line segment are not significantly different.

Figure 6. Results of post hoc Duncan's Multiple Range Test for MSES – Part II mean scores for temperament groups.

score falls in the "Little Confidence" category. For more discussion on this result, see Chapter V: Conclusions and Recommendations.

MBTI Temperament and MSES – Total

H_0: There are no significant differences in the mean MSES- Part Total scores for first and second semester calculus students with respect to their temperaments. This hypothesis will be tested using a three-way ANOVA. (Semester by Teaching Method by Temperament)

Fifty-four students answered both the MSES – Total and the MBTI. The temperament group means ranged from 6.3 to 7.2. The three-way analysis of variance for the model, Semester by Teaching Method by Temperament with MSES – Total scores, produced significant results for the class variable Semester with $p = 0.03$. For ANOVA summary table results, see Table 28.

A Duncan's Multiple Range Test to compare temperament group differences for MSES – Total found the semester means significantly different at the $\alpha = 0.05$ level of significance; however, the semester MSES – Total means ranged from 6.31 to 7.22 for the four temperament groups. Both of these means fall in the "Much Confidence" category; however, a comparison of the means for each semester resulted in a significant difference in the second semester. Note that this SP group was represented by one observation and had an MSES mean score of 4.2, which is significantly lower than the other groups in second semester, Calculus 142. The means for the temperament groups

Table 28

ANOVA Summary Table

Model: Semester by Teaching Method by Temperament

Dependent Variable: MSES – Total Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Groups	3.44	1	3.44	4.86	0.03
Between Treatments	1.07	1	1.07	1.52	0.22
Between Levels	2.06	3	0.69	0.98	0.41
Error	33.85	48	0.71		
Total	40.43	53			

Groups = Semester

Treatments = Teaching Method

Levels = Temperaments

for second semester calculus ranged from the low of 4.2, indicating "Some Confidence", to a high of 7.1 indicating "Much Confidence".

Pearson Correlation

Pearson product moment correlation coefficients were computed for the dependent variables MSES – Part I, MSES – Part II, MSES – Total, ACT mathematics scores, and calculus test. These results were tested against an $\alpha = 0.05$ level of significance. Mathematics Self-Efficacy Part II and MSES – Total were both significantly correlated with the calculus test scores; however the correlations were moderate at $r = 0.39$ and $r = 0.33$, respectively. MSES – Part I and MSES – Part II were significantly correlated with MSES – Total at r = 0.82 and 0.83 but were moderately correlated with each other. No other significant correlations were found among the dependent variables (see Table 29).

Summary

In summary, ACT Mathematics scores were not significantly different for learning styles or temperaments and were not used as a covariate in any subsequent analysis. Teaching

Table 29

Pearson Correlation Coefficients for Dependent Variables
r
p-value
n

	ACT Mathematics Score	MSES Part I	MSES Part II	MSES Total	Calculus Test
ACT Mathematics Score	--------	0.01 0.94 52	0.03 0.86 53	0.008 0.96 52	0.19 0.14 61
MSES Part I		--------	0.43 0.001 57	0.82 <0.0001 57	0.10 0.45 57
MSES Part II			-------	0.86 <0.0001 57	0.39 0.002 58
MSES Total				--------	0.33 0.01 57
Calculus Test					--------

method was not significantly different for any comparison. The hypotheses with learning style as one of the class variables were broken into four separate hypotheses, one for each dimension of learning style; therefore, the summary consists of 20 separate hypotheses for that class variable. In order to expediently summarize these results, refer to Table 30. Each hypothesis of the study is listed and labeled as “reject” or “fail to reject”.

With respect to the calculus test, the independent variables of interest were teaching method, learning style of the students, and temperament of the students. The results for three of the learning style dimensions were with respect to significantly different semester means; however, the different semester test means were not of primary interest. For the Dimension 1 alternatives, the reflective learners scored significantly higher than the active learners on the second semester calculus test. With respect to temperaments, the overall SP temperament calculus means were significantly lower, with the one SP (artisan) student in the second semester scoring significantly lower than the remaining three categories of temperaments. However, note that there was only one observation for second semester and only three observations for the SP category for the entire study.

Mathematics self-efficacy had mixed results. For MSES – Part I, reflective learners scored significantly higher than the active alternative. During the second semester, the global learners scored significantly higher than the sequential learners. For MSES – Part II, the global learner and sequential learner means were significantly different; however means in the range of 6.0 to 7.9 are within the same “Much Confidence” category of the MSES. For MSES – Total, all learning style dimension

Table 30

Summary of Hypotheses

ACT Mathematics Scores, Calculus Test, MSES – Part I, Part II, and Total

Hypothesis	Reject	Fail to Reject
Learning Styles and ACT Mathematics Scores H_0: There are no significant differences in the mean ACT mathematics scores for the first and second semester calculus students with respect to the four learning styles.		
Dimension 1		X
Dimension 2		X
Dimension 3		X
Dimension 4		X
Learning Styles and Calculus Test H_0: There are no significant differences in the mean calculus test scores for the first and second semester calculus students with respect to the four learning styles.		
Dimension 1	X	
Dimension 2	X	
Dimension 3	X	
Dimension 4	X	
Learning Styles and MSES – Part I H_0: There are no significant differences in the mean MSES – Part I scores for the first and second semester calculus students with respect to the four learning styles.		
Dimension 1		X
Dimension 2		X
Dimension 3	X	
Dimension 4	X	
Learning Styles and MSES – Part II H_0: There are no significant differences in the mean MSES – Part II scores for the first and second semester calculus students with respect to the four learning styles.		
Dimension 1		X
Dimension 2		X
Dimension 3		X
Dimension 4	X	

Table 30

(Continued)

ACT Mathematics Scores, Calculus Test, MSES – Part I, Part II, and Total

Hypothesis	Reject	Fail to Reject
Learning Styles and MSES – Total H_0: There are no significant differences in the mean MSES - Total scores for the first and second semester calculus students with respect to the four learning styles.		
Dimension 1	X	
Dimension 2	X	
Dimension 3	X	
Dimension 4	X	
Temperament ACT Mathematics Scores H_0: There are no significant differences in the mean ACT mathematics scores for first and second semester calculus students with respect to temperaments		X
Temperament and Calculus Test H_0: There are no significant differences in the mean calculus test scores for first and second semester calculus students with respect to their temperaments.	X	
Temperament and MSES – Part I H_0: There are no significant differences in the mean MSES- Part I scores for first and second semester calculus students with respect to their temperaments.		X
Temperament and MSES – Part II H_0: There are no significant differences in the mean MSES- Part II scores for first and second semester calculus students with respect to their temperaments.	X	
Temperament and MSES – Total H_0: There are no significant differences in the mean MSES- Total scores for first and second semester calculus students with respect to their temperaments.	X	

alternative semester means were significantly different; however, all of the means fell in the "Much Confidence" category.

For the MSES – Part I means with respect to the personality temperaments, the SP temperament mean of 5.3 was not only a statistically significant difference, but also a mean that placed in the lower category of "Some Confidence" while the remaining three groups fell in the "Much Confidence" category. The second semester SP student, whose mean was significantly lower, had a mean of 3.75 for the MSES – Total. This score is in the "Little Confidence" category – the lowest mean score of all student participants.

The preceding summary has been a synopsis of the results of the twenty-five hypotheses of concern for this study. For a discussion of the conclusions and recommendations, see Chapter V: Conclusions and Recommendations.

Chapter V

CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

Introduction

The primary purpose of this study was to determine the relationship between learning style preferences, personality temperament types, and mathematics self-efficacy on the achievement and course completion rate of a sample of the University of Tennessee at Knoxville college students enrolled in first and second semester calculus classes which utilized web-based materials. To achieve the purpose of this study, five instruments were used to collect data from students enrolled in a lecture/recitation and a web-based of first semester Calculus Math 141 class and a lecture/recitation and a web-based second semester Calculus Math 142 class for a total of four classes. The data collected included ACT mathematics scores, Myers-Briggs personality temperaments, mathematics self-efficacy scores, and calculus test scores.

Conclusions

Several conclusions, based on the data analyses and findings, have been formulated. These include:

- the necessity for post-secondary mathematics educators to address the issue of learning styles in their teaching.
- the need to investigate the decrease in female students and verbal learners in the second semester of calculus

Discussion

Due to the number of alternatives, the sample sizes in each category were small, ranging from one to twelve. Small sample sizes prohibited analyses for some categories. Analyses with samples of size three may only be indicative of a direction for further research. For instance, the overwhelming number of visual learners in Calculus 142 caused the researcher to question whether a significant number of those failing Calculus 141 were verbal learners. Recall that the failure rate for first semester calculus is approximately fifty percent. Only one of the Calculus 142 student participants was a verbal learner. With the overwhelmingly large number of visual learners, the expectation was that the web-based method of teaching would have produced significantly better calculus test grades; however, the variability in test scores was too large to show a significant difference, if one existed.

Global learners were significantly less in number than their sequential learner counterparts. These students are holistic systems thinkers by nature, who learn in large leaps, as opposed to the sequential learner students who learn in small steps. The supposition is that calculus can be taught from either a global or a sequential standpoint, depending on the instructor. The second semester global learner group from the lecture/recitation class scored lower than the second semester web-based calculus global group, 51.1 and 81.3, respectively. With the large variance and the small sample sizes of three and five, respectively, it was not possible to determine a difference, if one existed.

The SP (artisan) temperament represented by three of sixty-six students scored significantly lower on both the calculus test and the MSES. A student in this temperament group is more prone to major in fine arts, and students majoring in fine arts, rarely take a calculus class; however, one of the SP students reported that she came from a small private school and had a calculus background. When she entered college, her parents were trying to persuade her to be a veterinary medicine major. In an interview she reported that she was changing majors to art history at the end of the semester and "wished that she'd never signed up for calculus."

The significant drop in the percentage of female students from the Calculus 141 classes to the Calculus 142 classes is an area of concern. This research did not address the gender issue; however the decrease in female students in the second semester was an observation based on the data.

Although the data were somewhat inconclusive, due to small sample sizes in some groups, with respect to the benefits of the web-based instruction, the researcher holds to a strong belief that there is, in fact, a major benefit to some calculus students. There is a need for further research into the pedagogical uses of this medium. One conjecture is that computer based learning produces a sustained learning of materials, rather than the "memorize and regurgitate" phenomena that so often takes place in our lecture/recitation classes.

Recommendations

The use of web-based tutorials in the teaching of subjects is relatively new, and there is a tremendous need to continue research into the proper uses of the technology, specifically the use of the internet, with respect to the classroom or online, distance learning. Issues surrounding the availability and ease of use abound. Equipment reliability continues to be a problem. In spite of all the problems associated with use of technology in the classroom, these tools are available to enhance teaching and to reach students in ways that have yet to be discovered. The limitations that exist are those imposed by the educator's inability to design for optimal use, rather than the computer's inability to perform the task. As with any new field of study, time is necessary for the practitioners in the field to learn how to best utilize the advances in the area. Both software and equipment are rapidly changing. Next generation computers are becoming available on a monthly basis, and software revisions are flooding the marketplace. In many respects, the early users of the internet are neophytes compared to the newest techniques in utilizing the capabilities of both the equipment and the software.

In November, 2000 a small group of people who utilize technology in innovative ways to convey mathematics, met in Portugal to share ideas and techniques for utilizing educational technology. One computer science doctoral candidate demonstrated a new methodology for image-mapping video that was embedded into a web site. Many were using computers in their teaching of mathematics and innovative ways of doing research. The educational community is developing newer, better ways to teach with technology, which in turn creates a need for research in the ways to optimally use both the hardware and the software.

This foray into educational research with respect to the teaching of collegiate calculus has produced insights into future directions for this research. Some of those areas for improvement were noted for future research. The areas include:

1. using differences between a pre-test and a post-test to measure calculus achievement,
2. investigating the use of a different learning styles instrument,
3. using nested design of experiments with the same calculus professor for both lecture/recitation and web-based calculus classes,
4. recruiting more students within each university and recruiting professors from other universities,
5. interviewing more students,
6. tracking the number of times the website was accessed and the amount of time spent on each page of access, and

7. changing the mathematics self-efficacy instrument to a Likert-type scale of one to five, and constructing the instrument to reflect tasks associated with the specific calculus topics.

Near the end of every semester, students are requested to evaluate their instructors. As part of that evaluation, some instructors request the students to fill out a "Student Comment Sheet". One of the questions is "What aspects of this class contributed most to your learning?" A majority of the students in both semesters of the web-based calculus class stated that the web-based aspect of the class was the most helpful. There were a variety of reasons given for this statement that included being able to practice problems in an interactive environment with immediate feedback, being able to visualize results, and the ability to review the topics after class. The author of the website has received numerous communications from students who have found the site and improved their calculus grades from failing to grades of "A" or "B". It is apparent that some students have greatly benefited from this web site, and the question remains as to why some and not others. Feedback from students and the results of this research have provided information for the improvement of the web site. The planned changes to the Visual Calculus website include:

1. adding sound to facilitate verbal learners,
2. breaking example problems into more steps with associated written and oral explanations, and
3. incorporating online quizzes.

When this study began, there were very few studies concerning the use of web-based learning and calculus. There were a large number of studies with respect to utilizing calculators in the teaching of calculus. Utilizing the web for instructional purposes was a new endeavor. Most post-secondary mathematics educators are designing web sites with no particular thought to the proper pedagogical uses of multimedia. In many cases instructors have merely put online those handouts that are normally given to students during the first days of class, such as the syllabus, homework assignments, and class schedules. Many times multimedia is not utilized in the dynamic manner that is possible, such as demonstrating concepts in three dimensions. Research in the areas of using internet or web technology is relatively new and reports are generally anecdotal. Numerous listservs exist to provide educators a place to exchange ideas and glean information concerning the theory of learning and the uses of the internet. Research has just begun into the online learning environment, and controversies prevail as to the best format for the use of this dynamic media for instructional purposes; however the demographics of the post-secondary student is changing, thereby necessitating universities to change in order to meet the needs of their student clientele. Some colleges are offering online courses in order to meet the needs of students in a wider geographic region. Post-secondary institutions offer entire degree programs in an online environment, both asynchronously and synchronously. Colleges and universities have established new divisions to address online learning needs. These advances and changes necessitate research as to how best to manage these continuing changes.

Many times in industry a popular method of experimentation is the Taguchi Method in which one observation is taken for each combination of factors. The data collected is used to provide enough information to point the researcher in a future direction. If this study with its small number of observations in some groups is sufficient to indicate other areas of research, it has served a useful purpose. Presently, this researcher is aware of three grant proposals that are using the information from this study as background information in support of further research. The authors of these grants are interested in facilitating both high school and college mathematics students as they endeavor to pursue a better understanding of mathematics.

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APPENDICES

APPENDIX A

Myers Briggs Personality Type Definitions

Myers-Briggs Type Indicator (MBTI)

The MBTI is an instrument to describe one's personality type, based on the psychological type theory of Jung. Four dimensions of the personality are scored (See below.) resulting in sixteen different personality types – ISTJ, ISFJ, INFJ, INTJ, ISTP, ISFP, INFP, INTP, ESTP, ESFP, ENFP, ENTP, ESTJ, ESFJ, ENFJ, AND ENTJ.

Introversion (I) – Extroversion (E) Dimension

Introversion (I)

One who draws strength from within, or one who focuses on the inner world of ideas or impressions.

Extroversion (E)

One who draws his/her strength from people.

Sensing (S) – Intuition (N) Dimension

Sensing (S)

One who focuses on concrete information.

Intuition (N)

One who focuses on the future with an emphasis on patterns and possibilities.

Thinking (T) – Feeling (F) Dimension

Thinking (T)

One who makes decisions based on logic and objective analysis.

Feeling (F)

One whose decisions are based on what is best for people and society.

Judging (J) – Perceiving (P) Dimension

Judging (J)

One who likes a plan and an organized approach to life.

Perceiving (P)

One who is flexible and spontaneous in his/her approach to life.

Temperaments

Expounding on Myers and Briggs' personality types, Keirsey and Bates (1978) defined temperament as "that which places a signature or thumbprint on one's own actions, making it recognizably one's own." Kroeger and Thueson (1988) defined temperament with respect to the manner in which data are gathered and analyzed. Breaking the sixteen personality types into groups of people who respond in a similar fashion results in the following four temperaments: NF (idealist), NT (rational), SP (artisan), and SJ (guardian).

NF (idealist)

An NF or idealist temperament is an intuitive person who sees the "big picture" and translates the vision into actions that will benefit society. People having this temperament are abstract and conceptual. They make up approximately 12% of the U.S. population.

NT (rational)

The rational person is described as an analytical, systematic, abstract, theoretical, intellectual, complex, competent, inventive, logical, scientific, research-oriented person. They make up approximately 12% of the U.S. population.

SJ (guardian)

The SJ is practical and realistic, preferring organization and structure. They are described as conservative, stable, consistent, preferring routine, sensible, factual, unimpressive, dependable, hardworking, and detailed. They make up approximately 38% of the U.S. population.

SP (artisan)

The artisans are said to be spontaneous, flexible in their daily living, open-minded, easy-going, unprejudiced, persuasive, athletic, artistic, and living life for the day. They make up approximately 35% of the U.S. population.

APPENDIX B

Felder-Silverman ILS

INDEX OF LEARNING STYLES*

Barbara A. Soloman
First-Year College
North Carolina State University
Raleigh, North Carolina 27695

Richard M. Felder
Department of Chemical Engineering
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Raleigh, NC 27695-7905

DIRECTIONS

Circle "a" or "b" to indicate your answer to every question. Please choose only one answer for each question.

If both "a" and "b" seem to apply to you, choose the one that applies more frequently.

1. I understand something better after I
   (a) try it out.
   (b) think it through.

2. I would rather be considered
   (a) realistic.
   (b) innovative.

3. When I think about what I did yesterday, I am most likely to get
   (a) a picture.
   (b) words.

4. I tend to
   (a) understand details of a subject but may be fuzzy about its overall structure.
   (b) understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
   (a) talk about it.
   (b) think about it.

6. If I were a teacher, I would rather teach a course
   (a) that deals with facts and real life situations.
   (b) that deals with ideas and theories.

7. I prefer to get new information in
   (a) pictures, diagrams, graphs, or maps.
   (b) written directions or verbal information.

8. Once I understand
   (a) all the parts, I understand the whole thing.
   (b) the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
   (a) jump in and contribute ideas.
   (b) sit back and listen.

10. I find it easier
    (a) to learn facts.
    (b) to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
    (a) look over the pictures and charts carefully.
    (b) focus on the written text.

12. When I solve math problems
    (a) I usually work my way to the solutions one step at a time.
    (b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
    (a) I have usually gotten to know many of the students.
    (b) I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
    (a) something that teaches me new facts or tells me how to do something.
    (b) something that gives me new ideas to think about.

15. I like teachers
    (a) who put a lot of diagrams on the board.
    (b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
    (a) I think of the incidents and try to put them together to figure out the themes.
    (b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
    (a) start working on the solution immediately.
    (b) try to fully understand the problem first.

18. I prefer the idea of
    (a) certainty.
    (b) theory.

19. I remember best
    (a) what I see.
    (b) what I hear.

20. It is more important to me that an instructor
    (a) lay out the material in clear sequential steps.
    (b) give me an overall picture and relate the material to other subjects.

21. I prefer to study
    (a) in a study group.
    (b) alone.

22. I am more likely to be considered
    (a) careful about the details of my work.
    (b) creative about how to do my work.

23. When I get directions to a new place, I prefer
(a) a map.
(b) written instructions.

24. I learn
(a) at a fairly regular pace. If I study hard, I'll "get it."
(b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
(a) try things out.
(b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
(a) clearly say what they mean.
(b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
(a) the picture.
(b) what the instructor said about it.

28. When considering a body of information, I am more likely to
(a) focus on details and miss the big picture.
(b) try to understand the big picture before getting into the details.

29. I more easily remember
(a) something I have done.
(b) something I have thought a lot about.

30. When I have to perform a task, I prefer to
(a) master one way of doing it.
(b) come up with new ways of doing it.

31. When someone is showing me data, I prefer
(a) charts or graphs.
(b) text summarizing the results.

32. When writing a paper, I am more likely to
(a) work on (think about or write) the beginning of the paper and progress forward.
(b) work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
(a) have "group brainstorming" where everyone contributes ideas.
(b) brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
(a) sensible.
(b) imaginative.

35. When I meet people at a party, I am more likely to remember
(a) what they looked like.
(b) what they said about themselves.

36. When I am learning a new subject, I prefer to
(a) stay focused on that subject, learning as much about it as I can.
(b) try to make connections between that subject and related subjects.

37. I am more likely to be considered
    (a) outgoing.
    (b) reserved.

38. I prefer courses that emphasize
    (a) concrete material (facts, dat(a).
    (b) abstract material (concepts, theories).

39. For entertainment, I would rather
    (a) watch television.
    (b) read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
    (a) somewhat helpful to me.
    (b) very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
    (a) appeals to me.
    (b) does not appeal to me.

42. When I am doing long calculations,
    (a) I tend to repeat all my steps and check my work carefully.
    (b) I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
    (a) easily and fairly accurately.
    (b) with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
    (a) think of the steps in the solution process.
    (b) think of possible consequences or applications of the solution in a wide range of areas.

APPENDIX C

Mathematics Self-Efficacy Scale (MSES)

Name or I.D.____

Part I

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

How much confidence do you have that you could successfully:

1. Add two large numbers (e.g., 5379 + 62543) in your head........................	0	1	2	3	4	5	6	7	8	9
2. Determine the amount of sales tax on a clothing purchase.................	0	1	2	3	4	5	6	7	8	9
3. Figure out how much material to buy in order to make curtains.	0	1	2	3	4	5	6	7	8	9
4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest.........	0	1	2	3	4	5	6	7	8	9
5. Multiply and divide using a calculator.	0	1	2	3	4	5	6	7	8	9
6. Compute your car's gas mileage.	0	1	2	3	4	5	6	7	8	9
7. Calculate recipe quantities for a dinner for 3 when the original recipe is for 12 people........................	0	1	2	3	4	5	6	7	8	9
8. Balance your checkbook without a mistake.	0	1	2	3	4	5	6	7	8	9
9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed...................	0	1	2	3	4	5	6	7	8	9

Go on to next page.

Name or I.D.____

Part I (Cont.)

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

How much confidence do you have that you could successfully:

10. Figure out how long it will take to travel from Columbus to Chicago driving at 55 mph.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
11. Set up a monthly budget for yourself taking into account how much money you earn, bills to pay, personal expenses, etc.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
12. Compute your income taxes for the year.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
13. Understand a graph accompanying an article on business profits.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
14. Figure out how much you would save if there is a 15% mark-down on an item you wish to buy.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
15. Estimate your grocery bill in your head as you pick up items.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
16. Figure out which of 2 summer jobs is the better offer: one with a higher salary but no benefits; the other with a lower salary but with room, board, and travel expenses included.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
17. Figure out the tip on your part of a dinner bill total split 8 ways.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
18. Figure out how much lumber you need to buy in order to build a set of bookshelves.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Go on to Part II.

MATHD Test Booklet

Name or I.D.____

Part II: Math Courses

Please rate the following college courses according to how much confidence you have that you could complete the course with a final grade of "A" or "B". Circle your answer according to the 10-point scale below:

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

19. Basic College Math........	0	1	2	3	4	5	6	7	8	9
20. Economics.....................	0	1	2	3	4	5	6	7	8	9
21. Statistics........................	0	1	2	3	4	5	6	7	8	9
22. Physiology.....................	0	1	2	3	4	5	6	7	8	9
23. Calculus.........................	0	1	2	3	4	5	6	7	8	9
24. Business Administration	0	1	2	3	4	5	6	7	8	9
25. Algebra II.......................	0	1	2	3	4	5	6	7	8	9
26. Philosophy.....................	0	1	2	3	4	5	6	7	8	9
27. Geometry.......................	0	1	2	3	4	5	6	7	8	9
28. Computer Science.........	0	1	2	3	4	5	6	7	8	9
29. Accounting.....................	0	1	2	3	4	5	6	7	8	9
30. Zoology..........................	0	1	2	3	4	5	6	7	8	9
31. Algebra I........................	0	1	2	3	4	5	6	7	8	9
32. Trigonometry.................	0	1	2	3	4	5	6	7	8	9
33. Advanced Calculus........	0	1	2	3	4	5	6	7	8	9
34. Biochemistry..................	0	1	2	3	4	5	6	7	8	9

You have now completed the Mathematics Self-Efficacy Scale.
Thank you for your cooperation.

MATHD Test Booklet

APPENDIX D

Mathematics 141, Calculus Test 4

Mathematics 141 December 3, 1999 Test #4

Name____

Answer ALL questions and show ALL work.

1. Using L'Hospital's Rule, find the following limits:

   i. $\lim_{x\to 0} \frac{x^3+3x}{e^x-1} =$

   ii. $\lim_{x\to 0} (1+3x)^{2/x} =$

2. Using Newton's method, find a root (correct to 10 decimal places) of the function $g(x) = x^2 - e^{3x}$ using the initial approximation $x = -1$. Write down all of the intermediate values and the formula which you used.

3. Let *f(x)* $= x^5 - 5x^3$.
   i. Graph *f(x)* with your calculator and sketch the graph on your paper.

   ii. Use *f'(x)* to determine exactly the intervals where *f(x)* is increasing and the intervals where *f(x)* is decreasing.

   iii. Use *f''(x)* to determine exactly the intervals where *f(x)* is concave up and the intervals where *f(x)* is concave down.

   iv. If *f(x)* is restricted to the interval $-2 \le x \le 2.5$ find the *x* value which gives the global maximum of *f(x)* and the *x* value which gives the global minimum of *f(x)*.

APPENDIX E

Mathematics 142, Calculus Test 4

Mathematics 142 April 26, 2000 Test #4

Name____

Answer ALL questions and show ALL work. NOTE: All numerical answers must be correct to FIVE decimal places unless stated otherwise.

1. Find the degree four Taylor polynomial for the function $f(x) = \sqrt[3]{x+8}$ centered at $a = 0$.

2. Use the Taylor series of sin(x) to find the Taylor series of the integral $\int x^2 \sin(5x^2)dx$.

3. Write the integral used to find the area bounded by the graph of $r = 3\sin(\theta)$. Evaluate this integral.

4. Write the integral used to find the area bounded by the small loop of the graph of $r = 7 + 9\cos(\theta)$. Do NOT evaluate this integral.

APPENDIX F

Calculus Course Information

Syllabus

Section: 62367

Time: MWF 11:15-12:05, T 10:10-11:00

Text: Calculus - Concepts and Contexts, James Stewart

Examinations: Four fifty minute exams during the semester. Students will be given at least one week's notice. There will be an optional two hour comprehensive exam during the Final Exam Period, Tuesday, December 14, 8:00-10:00 AM.

Grades: Each of the first four exams will be worth 100 points and the final will be worth either 100 or 200 points. If the grade on the final is higher than one of first four exams, the lowest score of the first four exams will be eliminated and the final would count 200 points; if the grade on the final is lower than all of the first four exams, no scores would be eliminated but the final will only count 100 points. No makeup exams will be given (except under very unusual circumstances); if an exam is missed then the final must be taken and the missed exam will be the exam eliminated.

Homework should be prepared to be turned in. Many of the homework problems will be put on the board by students (see details below). The homework grade will count for 50 points. No late homework will be accepted.

An additional 50 points will be available for extra assignments.

The score out of 600 points (with final) or 500 points (without final) will be used to determine the final grade:

With Final:	564-600	528-563	492-527	456-491	420-455	390-419	0-389
Without Final:	470-500	440-469	410-439	380-409	350-379	325-349	0-324
Grade:	A	B+	B	C+	C	D	F

Graphing Calculator: A graphing calculator is required for the course. The Mathematics Department recommends the TI-86. Certain graphing calculators including the TI-89 and the TI-92 cannot be used on exams.

Internet: We will be making extensive use of materials on the Internet. The URL for the course is http://online.utk.edu/courses/60922/

Student Responsibilities: I expect that students will spend a minimum of 8 hours per week outside of class on this course, will read the section before I cover it in class and make a reasonable attempt to work the assigned homework problems.

Homework: There is only one way to learn mathematics and that is by doing mathematics! With a few exceptions, homework is due the second class period after which it is assigned. The reason for this is that if you have difficulty with any problem then you can seek help from the instructor or other sources before it is due. Many of the homework problems will be put up on the board by the students. Homework will also be collected and selected problems checked. As long as the student makes a reasonable attempt in working the problems and respond to questions satifactorily when at the board, the student will receive full credit. Absence or failure to put a problem on the board will result in a grade of 0 for the assignment.

Note. The part of the final grade for homework is 50 points. This will be determined by the formula:

Final grade for HW = 50 * (Points received on HW)/(Total possible)

The grade on the computer is the Points received on HW.

Snow Policy: Instructor will make every attempt to hold class if the university is holding classes. Exams will be postponed if it is snowing heavily or if it is the day after a heavy snowfall.

Syllabus

Section: 62367

Time: MWRF 11:15-12:05

Text: Calculus - Concepts and Contexts, James Stewart

Examinations: Four fifty minute exams during the semester. Students will be given at least one week's notice. There will be an optional two hour comprehensive exam during the Final Exam Period, Tuesday, May 9, 8:00-10:00 AM.

Grades: Each of the first four exams will be worth 100 points and the final will be worth either 100 or 200 points. If the grade on the final is higher than one of first four exams, the lowest score of the first four exams will be eliminated and the final would count 200 points; if the grade on the final is lower than all of the first four exams, no scores would be eliminated but the final will only count 100 points. No makeup exams will be given (except under very unusual circumstances); if an exam is missed then the final must be taken and the missed exam will be the exam eliminated.

Homework should be prepared to be turned in. Many of the homework problems will be put on the board by students (see details below). The homework grade will count for 50 points. No late homework will be accepted.

An additional 50 points will be given for online quizzes. You will be allowed multiple attempts.

The score out of 600 points (with final) or 500 points (without final) will be used to determine the final grade:

With Final:	564-600	528-563	492-527	456-491	420-455	390-419	0-389
Without Final:	470-500	440-469	410-439	380-409	350-379	325-349	0-324
Grade:	A	B+	B	C+	C	D	F

Graphing Calculator: A graphing calculator is required for the course. The Mathematics Department recommends the TI-86. Certain graphing calculators including the TI-89 and the TI-92 cannot be used on exams.

Internet: We will be making extensive use of materials on the Internet. The URL for the course is http://online.utk.edu/courses/60708/

Student Responsibilities: I expect that students will spend a minimum of 8 hours per week outside of class on this course, will read the section before I cover it in class and make a reasonable attempt to work the assigned homework problems.

Homework: There is only one way to learn mathematics and that is by doing mathematics! With a few exceptions, homework is due the second class period after which it is assigned. The reason for this is that if you have difficulty with any problem then you can seek help from the instructor or other sources before it is due. Many of the homework problems will be put up on the board by the students. These students will then be required to turn in the entire assignment to the instructor (right after putting problem on the board). As long as the student makes a reasonable attempt in working the problems and respond to questions satisfactorily, the student will receive full credit. Absence or failure to put a problem on the board will result in a grade of 0 for the assignment.

Snow Policy: Instructor will make every attempt to hold class if the university is holding classes. Exams will be postponed if it is snowing heavily or if it is the day after a heavy snowfall.

Course Diary

November 22

Started on Section 4.2. Covered finding maximum and minimum values of a function on a closed interval.

H.W.: p. 279 5, 11, 12, 37, 38, 41, 52, 53

November 19

Discussed homework problems from Section 4.1.

November 17

Test #3

November 16

Review for Test

November 15

Completed Section 4.1. (due Friday)

H.W.: p. 272 13, 14, 17, 21, 23, 24

November 12

Started Section 4.1.

H.W.: p. 272 1, 3, 5, 6, 7, 8

November 10

Continued with Section 3.8 and linear approximations. Introduced differentials.

H.W. p. 258: 7, 8, 10, 13, 14, 15, 16

November 9

Finished Section 3.7 and started on Section 3.8. Completed logarithmic differentiation and discussed linear approximations.

H.W. p. 246: 25, 26, 28, 30

p. 252: 2, 8, 12, 14, 25, 26, 27, 28

p. 258: 2, 4

November 8

Started Section 3.7; discussed derivatives of inverse functions and started on logarithmic differentiation.

November 5

Continued with implicit differentiation and discussed derivatives of inverse trigonometric functions.

November 3

Finished tangent lines to polar curves and started on Section 3.6. Covered implicit differentiation.

H.W.: p. A63 36, 38, 40; p. 245 3, 4, 14, 15, 21, 22

November 2

Continued with the discussion on Tangent Lines and Parametric Curves and started Appendix G, Section 1. Covered tangent lines to polar curves. Check out the review of polar coordinates.

November 1

Continued with the Chain Rule and started the discussion on Tangent Lines and Parametric Curves.

H.W.: p. 234 45, 54, 61, 62, 63, 64, 69, 70

October 29

Started Section 3.5. Covered Chain Rule.

H.W.: p. 234 7, 8, 9, 10, 13, 14, 19, 20
October 27
Covered Section 3.4. Covered the derivatives of trigonometric functions.
H.W.: p. 225 4, 8, 10, 18, 24, 26, 30, 32, 38, 42
October 26
Covered Section 3.3.
H.W.: p.217 2, 5, 6, 11, 12, 14, 19, 20
October 25
Discussed the test and homework.
October 20
Covered Section 3.2. Covered product rule and the quotient rule.
H.W.: p.206 3, 4, 6, 16, 26, 29, 32, 33, 37, 38
October 19
Started on section 3.1. Covered elementary differentiation formulasand the
derivative of the exponential function.
H.W.: p.199 7, 8, 9, 11, 17, 18, 19, 20, 30, 38, 43, 49, 58
October 18
Test #2.
October 15
Answer questions related to previous tests.
October 13
Finished section 2.10.
October 12
Finished section 2.10. Discussed problems similar to those in the Quiz on
Derivatives and Graphing.
H.W. p.168: 3; p.180: 10; p.184: 38, 41
October 11
Continued section 2.10. Discussed graphs and derivatives (increasing and
decreasing functions) and graphs and derivatives (concavity).
H.W. p.169: 33, 34, 35, 36
p.180: 11cd, 12cd, 21, 22
October 8
Finished section 2.8 and started on section 2.10. Discussed the definition of
the derivative of a function.
H.W. p. 180: 3, 6, 8, 11ab, 12ab
October 6
Completed section 2.7 and started on section 2.8. Discussed finding
derivatives at a point and definition of the derivative of a function.
H.W. p. 168: 17, 18, 19, 20, 21, 22, 43, 44, 45
October 5
Completed section 2.6 and started on section 2.7. Discussed velocity and other
rates of change.
H.W. p. 149: 13, 16, 20, 22
p. 156: 13, 14, 16, 17, 18, 19, 22
October 4
Started on section 2.6. Discussed tangent lines.
H.W. p. 149: 3, 4, 5, 6, 7, 8, 10
October 1

Continued with Section 2.5. Discussed vertical asymptotes and < a

href="/redirect?http://archives.math.utk.edu/visual.calculus/1/horizontal.5/">horizontal
asymptotes.
H.W. p. 140: 4, 13, 15, 16, 17, 18, 31, 32, 33, 40, 42
September 29
Finished Section 2.4 and started Section 2.5. Discussed the Intermediate Value
Theorem and vertical asymptotes.

September 28
Continued with Section 2.4. Continued with continuous functions.
H.W. p. 128: 31, 32, 33, 34, 37, 38, 43, 44
September 27
Finish Section 2.3 and start on Section 2.4. Finished symbolic calculations of
limits and started on continuous functions.
H.W. p. 128: 3, 5, 6, 11, 12, 14, 28, 29
September 24
Continued with Section 2.3. Finished limit theorems and started with symbolic
calculations of limits.
H.W. p. 118: 2, 5, 6, 9, 10, 14, 18, 20, 22, 26, 29, 34
September 22
Continued with Appendix D and started Section 2.3. Discussed the formal
definition of limits and limit theorems.
H.W. A38: 9, 10 and work through the drill on verifying limits.
September 21
Continued with Section 2.2 and started on Appendix D. Discussed a graphical
introduction to limits.
H.W. p. 109: 3, 5, 6
p. A38: 1, 2, 3, 4, 11, 12
September 20
Started Section 2.2. Discussed a numerical introduction to limits.
H.W. p.109: 9, 10, 12, 14b, 15a, 18a
September 17
Test #1
September 15
Went over the Review problems 17-33 and answered questions about old tests.
September 14
Went over homework problems from Section 1.6 and covered 1-16 of the Review
problems.
September 13
Finished Section 1.6.
September 10
Covered Section 1.6; discussed
Inverses of Functions
Logarithms
H.W.: p.73 6, 7, 9, 10, 13, 17, 23, 28, 32, 42, 54, 57, 58

September 8
Discussed homework problems.
September 7
Covered Section 1.5; discussed Exponential Functions.
H.W.: p.62 3, 4, 6, 7, 8, 9, 10, 14, 16, 18
September 3
Covered Section 1.4; discussed Parametric Equations.
H.W.: p.53 1, 6, 12, 13, 18, 19, 20
September 1
Covered Section 1.3; discussed
how computers and draw graphs and the problems associated with this process,

functions and parameters
The student is responsible for reading finding the intersections of graphs of
functions.
H.W. p.47: 24, 25, 26, 27, 28, 30, 32
August 30
Started on Section 1.2
Polynomials
Rational functions
Geometric Transformations of Functions

H.W. p.38: 6, 7, 8, 9, 10, 16, 17, 20, 21
August 27
Finished Section 1.1
Definition of Functions
Piecewise Defined Functions
Even and Odd Functions

H.W. p.24: 33, 34, 41, 42, 43, 46, 54, 58, 59, 60
August 25
Began Section 1.1 Definition of Functions.
H.W. p.23: 1,2,5,6,14,23,24,25,26

Course Diary

April 20

Continued with Areas Bounded by Polar Curves. (alternate site)

H.W. p.A69: 1, 3, 7, 11, 13, 14

April 19

Continued with Taylor polynomials and started on Areas Bounded by Polar Curves.

H.W. p.618: 15, 16, 17, 18, 29, 30, 45, 46, 47

April 17

Continued with integration, differentiation and representation of functions as power series and started on Taylor polynomials.

H.W. p. 607: 11, 12, 13, 19, 20

p. 619: Find the fifth degree Taylor polynomials for 15, 16; find the third degree Taylor polynomial for 17, 18.

April 14

Test #3

April 13

Reviewed for exam.

April 12

Continued with the discussion on Power Series and started the discussion on integration, differentiation and representation of functions as power series.

April 10

Continued with the discussion on Power Series.

H.W. p. 602: 5, 6, 7, 8, 12

April 7

Demonstrate some of the web resources which will be useful in studying for Test #3. Started the discussion on Power Series.

April 6

Continued the discussion on Ratio Test and started the discussion on Absolute Convergence.

H. W. p.596: 19, 20, 21, 22, 23, 24, 25, 27, 28, 31, 32

April 5

Continued the discussion on Alternating series (alternate site) and started the discussion on Ratio Test.

H. W. p. 595: 3, 5, 6, 7, 8, 9, 10, 12, 14

April 3

Continued the discussion on Limit Comparison Test (alternate site) and started the discussion on Alternating series (alternate site).

H.W. p. 595: 3, 5, 6, 7, 8, 9, 10, 12, 13

March 31

Continued the discussion on the Comparison Test (Alternate site) and started on Limit Comparison Test (alternate site).

H.W. p.588: 17, 18, 19, 20, 21, 22

March 29

Continued the discussion on the Integral Test and started the discussion on
the Comparison Test.
H.W. p.588: 11, 12, 13, 14, 15, 16, 24, 25, 26, 27,
March 27
Start the discussion on the Integral Test.
H.W. p.588: 1, 2, 6, 7, 8, 9, 10, 17, 23
March 17
Finish the discussion on Series.
March 16
Start the discussion on Series.
H.W. p.577: 9, 10, 11, 12, 13, 14, 19, 23, 24, 31, 32
March 15
Finished the discussion on sequences.
H.W. p.567: 23, 24, 25, 26, 37, 38, 40
March 13
Started the discussion on sequences.
H.W. p.567: 9-20
March 10
Test #2
March 9
Went over homework and reviewed for test.
March 8
Finished the discussion on work and started the discussion on Moments and
Center of Mass.
March 6
Started the discussion on work.
H.W. p.482: 1, 2, 3, 4, 11, 13, 14, 17
March 3
Finished discussing finding arc length and started on the average value of a
function.
H.W. p.472: 1, 3, 11, 16
March 2
Discussed finding arc length.
H.W. p.468: 2b, 3, 4, 14, 15
March 1
Finished discussing finding volumes by the washer or slab method and discussed
finding volumes using the cylindrical shell method.
H.W. p.462: Use cylindrical shell method on 3, 7, 8, 39, 40.
February 28
Discussed finding volumes.
H.W. p.462: 2, 3, 4, 5, 6, 9, 12
February 25
Discussed Area Bounded by a Parametric Curve and started the discussion on
finding volumes.
H.W. p.453: 27, 28; p.462: 20, 21, 22, 24
February 24
Continued the discussion on finding the area between two curves and discussed
finding the area of a circle.

February 23
Started the discussion on finding the area between two curves.
H.W. p.453: 9, 10, 12, 13, 18, 21, 22, 23
February 21
Continued discussing Improper Integrals.
H.W. p.435: 23, 24, 26, 27, 28, 47, 48
February 18
Discussed Improper Integrals.
H.W. p.435: 5, 6, 8, 13, 16, 21
February 17
Discussed Error Bounds of Numerical Integration.
H.W. p.425: 13, 14, 15, 16
February 16
Continued with Numerical Integration.
H.W. p.425: 2, 3, 5, 6, 23, 24
February 14
Test #1.
February 11
Discuessed old tests. Started on Numerical Integration.
February 10
Work homework problems and discuss old tests.
February 9
Continued with using Maple to evaluate integrals.
February 7
Finished Section Appendix F and started on using Maple to evaluate integrals.
H.W. p. A54: 26, 27, 28
February 4
Continued with Section Appendix F. Discussed Partial Fractions.
H.W. p. A54: 15, 18, 19, 20, 23, 24
February 3
Started on Section Appendix F (p.A46). Discussed Partial Fractions.
H.W. p. A54: 13, 14, 16, 17
February 2
Finished Section 5.6. Discussed Reduction Formulas.
H.W. p. 407: 35, 36, 37, 39, 40
January 31
Continued with Section 5.6. Continued discussing Integration by Parts.
H.W. p. 407: 5, 6, 12, 13, 14, 27, 41, 42
January 28
Started on Section 5.6. Discussed Integration by Parts.
H.W. p. 407: 2, 3, 4, 10, 11, 15, 22, 25, 26, 43
January 27
Continued with Section 5.5 and pg. A52 (in the Appendix). Continued discussing
Integration using Substitution.
H.W. p. 400: 39, 41, 58, 68, 69, 70
p. A54: 21, 22
January 26
Started on Section 5.5. Discussed Integration using Substitution.
H.W. p. 400: 7, 8, 10, 12, 13, 16, 18, 19, 25, 27, 28, 31
January 24
Completed Section 5.4 and started on Section 5.5. Discussed the second part of

the Fundamental Theorem of Calculus.
H.W. p. 388: 8, 10, 14, 17, 18, 19, 20, 26
January 21
Started on Section 5.3. Discussed what the text calls the Evaluation Theorem;
most other texts refer to this as the first part of the Fundamental Theorem of
Calculus.
H.W. p. 380: 9, 13, 14, 18, 29, 30, 49, 50
January 20
Finished Section 5.1 and started on Section 5.2. Discussed evaluating Riemann
Sums using a calculator and defined the definite integral.
H.W. p. 360: 6, 7.
H.W. p. 370: 3, 4, 10, 11, 12.
January 19
Continued with Section 5.1. Discussed summations and Riemann Sums.
January 14
Started Section 5.1. Discussed Approximation of Areas.
H.W. p. 359: 2, 4.
January 13
Finished Section 4.9. Continued discussing antiderivatives followed by a
discussion of slope fields.
H.W. p. 338: 25, 26, 32, 37, 38, 40, 46
January 12
Started on Section 4.9. Discussed antiderivatives.
H.W. p. 338: 2, 4, 5, 8, 11, 16, 21, 22, 23

APPENDIX G

Descriptive Statistics for ILS

Semester	Teaching Methods	Learning Style	Mathematics ACT Score N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	Active	5	12	23	14.2	4.92
		Reflective	9	12	31	20.1	7.93
		Intuitive	3	12	12	12.0	0.00
		Sensing	11	12	31	19.6	7.58
		Visual	11	12	27	16.8	6.75
		Verbal	3	12	31	22.3	9.61
		Global	5	12	25	17.0	6.86
		Sequential	9	12	31	18.6	8.03
	B	Active	11	12	31	20.5	8.39
		Reflective	4	12	21	16.5	5.20
		Intuitive	11	12	31	21.2	7.91
		Sensing	4	12	22	14.5	5.00
		Visual	12	12	31	19.3	8.07
		Verbal	3	12	27	20.0	7.55
		Global	7	12	32	26.9	7.06
		Sequential	8	12	30	18.1	8.44
Spring, 2000	A	Active	7	12	27	18.3	6.34
		Reflective	6	12	28	18.7	7.55
		Intuitive	4	12	27	18.3	7.50
		Sensing	9	12	28	18.6	6.69
		Visual	12	12	27	17.7	6.24
		Verbal	1	12	28	28.0	0.00
		Global	3	12	22	18.7	5.77
		Sequential	10	12	28	18.4	7.15
	B	Active	7	12	30	20.4	10.63
		Reflective	6	12	26	16.5	6.98
		Intuitive	7	12	30	20.9	8.40
		Sensing	6	12	25	16.0	6.23
		Visual	13	12	30	18.6	7.60
		Verbal	0				
		Global	4	12	26	18.8	7.80
		Sequential	9	12	30	18.6	7.99

Semester	Teaching Methods	Learning Style	Calculus Test N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	Active	5	65	97	78.3	14.77
		Reflective	9	0	100	82.4	31.85
		Intuitive	3	65	92	76.1	13.88
		Sensing	11	0	100	82.3	29.27
		Visual	11	0	100	78.8	29.36
		Verbal	3	83	100	89.0	9.62
		Global	5	65	100	88.0	14.60
		Sequential	9	0	100	77.0	31.23
	B	Active	11	53	100	77.4	15.69
		Reflective	4	75	95	88.3	9.43
		Intuitive	11	53	100	77.9	16.06
		Sensing	4	70	98	85.0	12.08
		Visual	12	58	100	82.4	14.17
		Verbal	3	53	95	73.3	17.16
		Global	7	53	100	81.4	19.23
		Sequential	8	63	98	79.1	11.70
Spring, 2000	A	Active	7	23	97	48.6	33.66
		Reflective	6	73	100	87.2	10.63
		Intuitive	4	23	97	49.2	37.70
		Sensing	9	23	100	74.1	30.13
		Visual	12	23	100	64.7	32.67
		Verbal	1	87	87	87.0	
		Global	3	23	97	51.1	39.77
		Sequential	10	23	100	71.0	30.02
	B	Active	7	30	93	59.2	19.50
		Reflective	6	50	100	79.2	19.00
		Intuitive	7	50	93	73.3	16.90
		Sensing	6	30	100	65.0	25.39
		Visual	13	30	100	69.2	21.27
		Verbal	0				
		Global	4	57	100	81.3	16.26
		Sequential	9	30	100	63.6	21.57

Semester	Teaching Methods	Learning Style	MSES - Part I				
			N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	Active	5	6.0	8.7	7.28	0.98
		Reflective	9	5.1	8.8	7.40	1.22
		Intuitive	3	6.0	8.7	7.19	1.39
		Sensing	11	5.1	8.8	7.40	1.09
		Visual	11	6.0	8.8	7.54	0.93
		Verbal	3	5.1	8.3	6.67	1.63
		Global	5	5.1	8.8	7.07	1.64
		Sequential	9	6.6	8.7	7.51	0.75
	B	Active	11	7.0	8.6	7.69	0.46
		Reflective	4	6.6	7.9	7.15	0.53
		Intuitive	11	7.0	8.6	7.56	0.54
		Sensing	4	6.6	8.0	7.50	0.55
		Visual	12	7.0	8.6	7.66	0.50
		Verbal	3	6.6	7.8	7.22	0.52
		Global	7	7.1	8..6	7.67	0.57
		Sequential	8	6.6	8.0	7.44	0.51
Spring, 2000	A	Active	7	6.0	8.8	7.60	1.17
		Reflective	6	6.0	7.6	6.87	0.62
		Intuitive	4	6.0	8.8	7.72	1.20
		Sensing	9	6.0	8.3	6.97	0.79
		Visual	12	6.0	8.8	7.33	0.92
		Verbal	1	6.0	6.0	6.00	
		Global	3	7.6	8.8	8.19	0.58
		Sequential	10	6.0	8.3	6.90	0.85
	B	Active	7	5.0	7.3	6.73	0.75
		Reflective	6	6.2	8.0	7.28	0.71
		Intuitive	7	6.2	8.0	7.06	0.63
		Sensing	6	5.0	7.9	6.94	0.91
		Visual	13	5.0	8.0	7.00	0.76
		Verbal	0				
		Global	4	6.2	8.0	7.30	0.73
		Sequential	9	5.0	7.7	6.87	0.77

Semester	Teaching Methods	Learning Style	MSES - Part II				
			N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	Active	5	5.6	8.1	6.58	1.26
		Reflective	9	5.4	8.7	7.10	1.06
		Intuitive	3	5.6	7.8	6.56	1.16
		Sensing	11	5.4	8.7	7.01	1.15
		Visual	11	5.6	8.7	7.07	1.16
		Verbal	3	5.4	6.9	6.31	0.83
		Global	5	5.4	8.7	6.93	1.62
		Sequential	9	5.6	8.1	6.90	0.83
	B	Active	11	4.7	7.6	6.63	0.92
		Reflective	4	5.9	6.9	6.45	0.50
		Intuitive	11	4.7	7.6	6.55	0.94
		Sensing	4	5.9	7.3	6.63	0.58
		Visual	12	4.7	7.6	6.64	0.88
		Verbal	3	5.6	7.1	6.42	0.69
		Global	7	5.6	7.6	6.89	0.98
		Sequential	8	4.7	7.4	6.38	0.88
Spring, 2000	A	Active	7	5.6	6.9	6.38	0.45
		Reflective	6	5.8	7.9	6.76	0.73
		Intuitive	4	6.1	6.8	6.36	0.29
		Sensing	9	5.6	7.9	6.65	0.69
		Visual	12	5.6	7.9	6.56	0.63
		Verbal	1	6.5	6.5	6.50	
		Global	3	6.3	7.9	6.96	0.83
		Sequential	10	5.6	7.3	6.44	0.51
	B	Active	7	3.4	7.4	6.16	1.26
		Reflective	6	6.2	8.1	6.13	1.65
		Intuitive	7	2.8	7.6	5.94	1.44
		Sensing	6	3.4	8.1	6.36	1.46
		Visual	13	2.8	8.1	6.15	1.42
		Verbal	0				
		Global	4	6.3	7.6	6.98	0.58
		Sequential	9	2.8	8.1	5.77	1.54

Semester	Teaching Methods	Learning Style	MSES - Total				
			N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	Active	5	6.0	8.5	7.16	1.04
		Reflective	9	5.4	8.7	7.10	1.15
		Intuitive	3	6.0	8.5	7.10	1.30
		Sensing	11	5.4	9.0	7.43	1.08
		Visual	11	6.0	9.0	7.54	1.01
		Verbal	3	5.4	7.9	6.70	1.29
		Global	5	5.4	9.0	7.21	1.67
		Sequential	9	6.7	8.5	7.45	0.70
	B	Active	11	6.4	8.0	7.31	0.57
		Reflective	4	6.6	7.2	7.03	0.29
		Intuitive	11	6.4	8.0	7.21	0.57
		Sensing	4	6.6	7.7	7.27	0.43
		Visual	12	6.4	8.0	7.32	0.56
		Verbal	3	6.6	7.2	7.00	0.28
		Global	7	7.0	8.0	7.50	0.45
		Sequential	8	6.4	7.6	7.02	0.47
Spring, 2000	A	Active	7	6.4	8.1	7.19	0.62
		Reflective	6	6.4	8.0	7.02	0.64
		Intuitive	4	6.4	8.1	7.30	0.72
		Sensing	9	6.4	8.0	7.01	0.57
		Visual	12	6.4	8.1	7.17	0.60
		Verbal	1	6.4	6.4	6.40	
		Global	3	7.5	8.1	7.84	0.30
		Sequential	10	6.4	7.7	6.86	0.46
	B	Active	7	4.2	7.3	6.46	0.97
		Reflective	6	5.4	8	6.77	0.94
		Intuitive	7	5.4	7.8	6.53	0.75
		Sensing	6	4.2	8	6.69	1.15
		Visual	13	4.2	8	6.61	0.94
		Verbal	0				
		Global	4	6.2	7.8	7.15	0.63
		Sequential	9	4.2	8	6.37	0.98

APPENDIX H

ANOVA Summary Tables

Learning Styles Dimensions and Mathematics ACT Scores

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 1: Active vs. Reflective

Dependent Variable: Mathematics ACT Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	0.47	1	0.47	0.92	0.93
Between Treatments	9.03	1	9.03	0.17	0.69
Between Levels	2.45	1	2.45	0.05	0.83
Error	2766.77	51	54.25		
Total	27778.73	54			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 1 Learning Styles

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 2: Intuitive vs. Sensing

Dependent Variable: Mathematics ACT Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	0.47	1	0.47	0.01	0.93
Between Treatments	9.03	1	9.03	0.17	0.68
Between Levels	26.99	1	26.99	0.50	0.48
Error	2742.23	51	53.77		
Total	2778.72	54			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 2 Learning Styles

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 3: Visual vs. Verbal

Dependent Variable: Mathematics ACT Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	0.47	1	0.47	0.01	0.92
Between Treatments	9.03	1	9.03	0.17	0.68
Between Levels	106.34	1	106.34	2.04	0.16
Error	2662.89	51	52.21		
Total	2778.73	54			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 3 Learning Styles

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 4: Global vs. Sequential

Dependent Variable: Mathematics ACT Scores					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	0.47	1	0.47	0.01	0.93
Between Treatments	9.03	1	9.03	0.17	0.69
Between Levels	3.51	1	3.51	0.06	0.80
Error	2765.72	51	54.23		
Total	2778.73	54			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 4 Learning Styles

APPENDIX I

ANOVA Summary Tables

Learning Styles Dimensions and Calculus Test

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 3: Visual vs. Verbal

Dependent Variable: Calculus Test					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	2329.52	1	2329.52	4.08	0.05
Between Treatments	12.33	1	12.33	0.02	0.88
Between Levels	37.96	1	37.96	0.07	0.80
Error	31365.29	55	565.98		
Total	33745.10	58			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 4 Learning Styles

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 4: Global vs. Sequential

Dependent Variable: Calculus Test					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	2329.52	1	2329.52	4.12	0.05
Between Treatments	12.33	1	12.33	0.02	0.88
Between Levels	274.16	1	274.16	0.48	0.49
Error	31129.09	55	565.98		
Total	33745.10	58			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 4 Learning Styles

APPENDIX J

ANOVA Summary Tables

Learning Styles Dimensions and MSES – Part I

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 1: Active vs. Reflective

Dependent Variable: MSES – Part I					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	1.70	1	1.70	2.29	0.14
Between Treatments	0.003	1	0.003	0.00	0.95
Between Levels	0.18	1	0.18	0.24	0.63
Error	38.67	52	0.74		
Total	40.55	55			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 1 Learning Styles

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 2: Intuitive vs. Sensing

Dependent Variable: MSES – Part I					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	1.70	1	1.70	2.30	0.14
Between Treatments	0.003	1	0.003	0.00	0.95
Between Levels	0.50	1	0.50	0.67	0.42
Error	38.34	52	0.74		
Total	40.55	55			

Groups = Semester

Treatments = Teaching Method

Levels = Dimension 2 Learning Styles

ANOVA Summary Table

Semester By Teaching Method By Learning Style Dimension

Dimension 4: Global vs. Sequential

Dependent Variable: MSES – Part I					
Source of Variation	Sums of Squares	Degrees of Freedom	Mean Square	F	p-value
Between Group	1.70	1	1.70	2.34	0.14
Between Treatments	0.003	1	0.003	0.00	0.95
Between Levels	0.14	1	0.14	1.57	0.22
Error	37.71	52	0.73		
Total	40.55	55			

Groups = Semester

Treatments = Teaching Method

Levels = 4 Learning Styles

APPENDIX K

Descriptive Statistics for Temperaments

Semester	Teaching Method	Temperament	Mathematics ACT Scores N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	NT Rational	1	12	12	12.0	
		NF Idealist	5	12	31	18.6	9.21
		SP Artisan	1	23	23	23.0	
		SJ Guardian	7	12	32	19.6	7.81
	B	NT Rational	8	12	30	23.7	7.03
		NF Idealist	7	12	31	20.6	8.44
		SP Artisan	0				
		SJ Guardian	3	12	27	20.3	7.64
Spring, 2000	A	NT Rational	1	12	12	12.0	
		NF Idealist	4	12	27	19.3	8.38
		SP Artisan	1	22	22	22.0	
		SJ Guardian	4	21	28	21.5	6.81
	B	NT Rational	4	12	30	20.0	9.38
		NF Idealist	4	23	28	25.5	2.08
		SP Artisan	1	12	12	12.0	
		SJ Guardian	4	12	12	12.0	0.00

Semester	Teaching Method	Temperament	Calculus Test N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	NT Rational	1	92	92	92.0	
		NF Idealist	5	0	100	69.3	40.15
		SP Artisan	1	67	67	67.0	
		SJ Guardian	7	65	100	85.6	14.36
	B	NT Rational	8	45	95	78.3	17.00
		NF Idealist	7	58	100	78.6	16.93
		SP Artisan	0				
		SJ Guardian	3	53	93	73.8	20.02
Spring, 2000	A	NT Rational	1	73	73	73.0	
		NF Idealist	4	43	100	79.2	26.02
		SP Artisan	1	33	33	33.0	
		SJ Guardian	4	87	97	92.5	5.00
	B	NT Rational	4	30	67	51.7	15.52
		NF Idealist	4	50	100	78.0	21.81
		SP Artisan	1	47	47	47.0	
		SJ Guardian	4	50	100	79.2	18.19

Semester	Teaching Method	Temperament	MSES Part I N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	NT Rational	1	6.8	6.8	6.80	
		NF Idealist	5	6.6	7.9	7.36	0.869
		SP Artisan	1	7.0	7.0	7.00	
		SJ Guardian	7	5.1	8.8	7.48	1.432
	B	NT Rational	8	7.0	8.6	7.41	0.589
		NF Idealist	7	7.5	8.0	7.74	0.389
		SP Artisan	0				
		SJ Guardian	3	6.6	7.8	7.35	0.651
Spring, 2000	A	NT Rational	1	6.8	6.8	6.80	
		NF Idealist	4	7.9	7.9	7.02	0.875
		SP Artisan	1	8.8	8.8	8.80	
		SJ Guardian	4	8.0	8.0	6.68	0.713
	B	NT Rational	4	6.4	7.2	6.94	0.342
		NF Idealist	4	6.2	7.9	7.11	0.682
		SP Artisan	1	5.0	5.0	5.00	
		SJ Guardian	4	6.2	8.0	7.29	0.620

Semester	Teaching Method	Temperament	MSES Part II				
			N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	NT Rational	1	6.4	6.4	6.40	
		NF Idealist	5	5.6	7.8	6.83	0.830
		SP Artisan	1	5.9	5.9	5.90	
		SJ Guardian	7	5.4	5.4	7.23	1.350
	B	NT Rational	8	6.0	7.1	6.80	0.402
		NF Idealist	7	4.7	7.6	6.39	1.131
		SP Artisan	0				
		SJ Guardian	3	5.6	7.3	7.23	1.365
Spring, 2000	A	NT Rational	1	6.4	6.4	6.40	
		NF Idealist	4	6.1	7.3	6.39	1.310
		SP Artisan	1	6.8	6.8	6.80	
		SJ Guardian	4	5.8	7.9	6.33	0.853
	B	NT Rational	4	6.4	6.4	6.09	0.242
		NF Idealist	4	2.8	7.1	6.59	0.532
		SP Artisan	1	3.4	3.4	3.40	
		SJ Guardian	4	5.8	8.1	6.85	0.982

Semester	Teaching Method	Temperament	MSES Part II N	MIN	MAX	Mean	Std Dev
Fall, 1999	A	NT Rational	1	6.8	6.8	6.80	
		NF Idealist	5	6.7	8.5	7.30	0.787
		SP Artisan	1	6.7	6.7	6.70	
		SJ Guardian	7	5.4	9.0	7.58	1.396
	B	NT Rational	8	6.5	8.0	7.23	0.482
		NF Idealist	7	6.4	8.0	7.25	0.606
		SP Artisan	0				
		SJ Guardian	3	6.6	7.7	7.09	0.536
Spring, 2000	A	NT Rational	1	6.8	6.8	6.80	
		NF Idealist	4	6.4	7.7	7.02	0.568
		SP Artisan	1	8.1	8.1	8.10	
		SJ Guardian	4	6.4	7.7	6.86	0.736
	B	NT Rational	4	6.3	6.8	6.54	0.228
		NF Idealist	4	5.4	7.5	6.54	0.900
		SP Artisan	1	4.2	4.2	4.20	
		SJ Guardian	4	6.2	8.0	7.11	0.693

VITA

D. Sharon Husch was born in Fancy Gap (Carroll Country), Virginia on November 9, 1947. She attended elementary school in Oak Ridge and Knoxville, Tennessee and high school in Knoxville, Tennessee and Niles, Michigan and was graduated from West High School, Knoxville, Tennessee, in June 1965.

She attended the University of Tennessee at Knoxville for two years and the University of Georgia at Athens for two years before receiving the Bachelor of Science in Education degree with a major in mathematics from the University of Georgia in June 1969. Since that time she has received a Master of Science degree in Curriculum from the University of Tennessee at Knoxville in 1980 and a Master of Science degree in Statistics from the University of Tennessee at Knoxville in 1988. In May, 2001 she received the Doctor of Philosophy degree in Education at the University of Tennessee at Knoxville.

She has taught science and mathematics for three years at the junior high level at Sacred Heart School, Knoxville, Tennessee, English as a Second Language and mathematics in K-2 for one year at the American School of Zagreb (Croatia), mathematics for four years at Knoxville Catholic High School, Knoxville, Tennessee where she was chairperson of the mathematics department for 3 years. She has also taught mathematics, computer literacy, and computer programming at Bearden High School, Knoxville, Tennessee, for five years, and mathematics for the University of Tennessee at Knoxville, both in the Evening School and for the Department of Mathematics, and statistics for the Department of Statistics. Presently, she is a lecturer for the Department of Mathematics at the University of Tennessee at Knoxville and the director of Our Father's Academy.

During the years of 1989 through 1996, she held the positions of plant statistician, process engineer, statistical engineer, senior statistical engineer, project manager, and quality leader for Corning, Incorporated.

Her professional affiliations include memberships in the National Council of Teachers of Mathematics, Association for Curriculum Development, Tennessee Mathematics Teachers Association, and the Association of Christian Schools International.

While a student at the University of Georgia at Athens, she met and married Dr. Lawrence S. Husch, Jr. They have two daughters, LoriAnne Faye and Donna Michelle, two sons-in-law, Alberto and Pablo, and six grandchildren, Samuel Uriah, Donna Elizabeth, Benjamin Zachary, Stephen Pascual, Ian Javel, and Isaac Isaiah.