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UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

IMPACT OF AN INTERNET PROJECT ON COLLEGE MATHEMATICS STUDENTS' DISCOURSE AND MEANING MAKING

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By

JACQUINITA A. ROSE
Norman, Oklahoma
2001

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IMPACT OF AN INTERNET PROJECT
ON COLLEGE MATHEMATICS STUDENTS'
DISCOURSE AND MEANING MAKING

A DISSERTATION
APPROVED FOR THE DEPARTMENT OF INSTRUCTIONAL LEADERSHIP
AND ACADEMIC CURRICULUM

By

Dr. M. Jayne Fleener

Dr. Anne Reynolds

Dr. Sandy Scaffetta Johnson

Dr. Charles Butler

Dr. Raymond B. Miller

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ABSTRACT

This study examined the impact of an Internet project on students': a) mathematical classroom discourse, b) meaning making of calculus concepts, c) relevancy of Calculus to students' area of interest and/or study, and d) beliefs about mathematics.

The two methods of data collection used for this study were surveying and interviewing. Surveys and questionnaires were used to obtain information regarding students' beliefs and/or opinions regarding mathematics. Interviews were used to probe students' perceptions and/or attitudes regarding writing in college mathematics courses as well as their opinions regarding the incorporation of research projects in mathematics classroom curriculum. Data was also collected from students' completed Internet Projects.

The collected data were analyzed using a thematic analysis based on the study's research question(s) and students' categorical responses. The findings of the study suggest that students, by incorporating an internet project to reinforce their mathematics instruction, speak of mathematics in a more positive nature and were able to find for themselves its connections to real-world situations and to their areas of study and/or personal interests. With regard to meaning making, the majority of students focused their efforts on finding out how Calculus impacted their current area of study and future career.

Recommendations for future research regarding students' meaning efforts included suggestions for possible holistic approaches as well as suggestions for more

student input into classroom curriculum design. Some examples include constructing a "textbook free" mathematics classroom.

Chapter I

Introduction

In the 21st century, mathematics educators are concerned with transforming mathematics curriculum and college classrooms so students can make meaning of what they are learning (Alessio, 1996; Elsberry & Lindsey, 1996; Kasturiarachi, 1997; Lai, 1996; O'Banion, 1997). The goals of the reform efforts are for students to be active participants in the classroom. Instructional strategies with these goals in mind are designed to provide opportunities for students to communicate orally and in writing by incorporating real world problems (Haver & Turbeville, 1995; Kirman, 1998, Schwartz, 1992). Our current curriculum structure is deeply rooted in modernist ideas about learning. The impact of the modern mind set includes curriculum and instructional strategies that are linear, sequential, fixed, and unyielding (Burton, 1995; Code, 1991; Collins, 1991; Doll, 1993). Within this curriculum framework, students are not encouraged to be actively engaged in their own learning. Rote memorization of algorithms and facts take precedence over mindful (Langer, 1997) and meaningful (Yackel & Cobb, 1996) approaches to mathematics learning.

In many college mathematics classrooms, especially entrenched in traditional approaches to mathematics teaching and learning, instructors dispense mathematical terms, facts, and procedures. Students view the instructors as the absolute authority or "expert" (Walkerdine, 1988; Code, 1991; Collins; Doll, 1993; Belenky, et al, 1986/1997)

and tend to accept the dispensed knowledge without question. Primarily, feedback, at a rudimentary level, consists of returned homework and tests and the occasional "Try harder"comments. The focus of the instructor's feedback is on correct answers; unique solution strategies are seldom encouraged or rewarded. Minimal or no dialogue takes place between the student and the instructor (Trice, Naudu, Lowe, & Joffee, 1996). In the traditional college mathematics classroom, neither student-student interaction nor instructor-student interaction is encouraged (Fasinger, 1995; Spangler, 1992; Thompson, 1984). Students are so busy writing down disconnected information that they have little time for in-depth discourse, discussion, questioning, and interaction with the instructor, other students in the class, or the mathematics they are learning. Students are so encumbered with learning rote procedures and memorizing mathematical concepts, which have little or no relevancy to their lives, that meaningful learning (Langer, 1997; Doll, 1993) does not occur.

The instructional strategies teachers choose are influenced by their perspectives on how students learn (Hoyles, 1992; Mura, 1993/1995; Ponte, et. al., 1994; Quinn, 1998; Silver, 1999;Vithal et. al., 1995), their beliefs about teaching, and their roles and responsibilities as the classroom instructional leader (Manouchehri & Goodwin, 1998; Manouchehri, 1998). For example, an instructor who views students as co-investigators in the learning process, who views herself as a facilitator, and who sees knowledge as something constructed through personal experience and interaction with others and with mathematics might incorporate learning activities and the use of manipulatives to help

students make connections between mathematical abstractions and real-world situations. A more traditional instructor may consider mathematics inquiry to be the domain of only a select few. The majority of students, they may feel: a) need to stay focused on the facts, b) rely on the teacher for determining what is important to learn, c) learn through practice and memorization, and d) count as evidence of learning correct application of appropriate and approved procedures to achieve the right answer to any given problem.

Assessing for Meaningful Learning

Traditionally, achievement and learning have been measured in terms of letter grades (Doll, 1993). How well a student does on exams and homework assignments determines her grade for the course. Grades are usually averaged and a percentage of the points translate to an assigned letter grade of A, B, C, D, or F. As changes occur in views about teaching and learning, instructors must change their assessment techniques to more adequately reflect students' growth and sense making (Cullen & Pratt, 1992).

NCTM, Curriculum and Evaluation Standards (1989), recommend that we focus on the following:

1) Assessing what students know and how they think about mathematics
2) Having assessment be an integral part of teaching
3) Focusing on a broad range of mathematical tasks and taking a holistic view of mathematics
4) Developing problem situations that require the application of a number of mathematical ideas

5) Using multiple assessment techniques, including written, oral, and demonstration formats

6) Using calculators, computers and manipulatives in assessment

7) Evaluating the program by systematically collecting information on outcomes, curriculum, and instruction

8) Using standardized achievement tests as only one of many indicators of program outcomes (p.191).

Students use a variety of ways to construct meaning and understanding in mathematics. To accommodate for the diversity of learning strategies, students and teachers may benefit from the use of multiple assessment strategies (Lesh & Lamon, 1992). There are many assessment strategies, such as the use of journals, portfolios, student projects, and class demonstrations. Journal writing is a way for the student to write and continually reflect upon their experiences with mathematics (Stewart & Chance, 1995). The instructor can use journals to gain insight into the students' development in the class as well as discern the students' understanding and learning of mathematical problems and ideas (Powell, 1997; Mayer & Hillman, 1996; Dougherty, 1996; Norwood & Carter, 1994; Stix, 1994). Journals are also an excellent way to open and maintain a channel of communication among students and instructors (Mayer & Hillman, 1997; Gordon & Macinnis, 1993). Portfolios can provide information about a student's growth over an extended period of time. Student portfolios can be used for self-assessment and reflection (Mayer & Hillman, 1997; Dougherty, 1996; Norwood & Carter, 1994). Cullen

& Pratt (1992) also encourage the use of student-teacher interviews and group projects as alternative ways of evaluating students' progress. Lester (1991) suggests that because students' ideas about mathematics develop over an extended period of time, to adequately assess their development, we need to develop techniques for assessing students' progress in mathematics that will provide a more comprehensive evaluation of students than just the traditional class exam (Lester, 1991).

Learning

Leaning is multifaceted and complex. Two components or perspectives of learning are rote and meaningful learning. Rote learning is the process of learning information without having any connection or relationship to existing information. This style of learning limits the students to simple recollection and regurgitation of facts or procedures. Rote learning does not afford students the opportunity to apply what they have learned to new ideas or concepts. However, rote learning does permit students to learn large amounts of data quickly and efficiently. Many suggest that when students depend solely on memorization problems can occur such as the inability for students to apply material to different concepts (Phillips & Soltis, 1998) or recall once learned methods of solution. A student can memorize mathematical tables but what happens to the student over time or when the context changes? For example if asked to add 7+ 6 a student typically will answer 13. However, consider the 12 hour clock where 7 o'clock + 6 hours is 1 am. Here memorization of tables does not necessarily help the student, but rather an understanding of the context and meaning in which the addition is being used is relevant to

solving the problem using modular arithmetic.

Meaningful learning occurs when learners are able to relate new ideas and concepts to material they have already learned. According to the NCTM Principles and Standards for School Mathematics (2000), "Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge. (p.6)" Students are engaged in meaningful learning when they can apply and connect new ideas and concepts about mathematics to ones previously learned and to situations that exist outside the controlled parameters of the classroom. These connections can help increase students' understanding of mathematics. Learning is not just regurgitation of facts and/or lengthy arduous theorems (Dewey, 1916/1963). Frankenstein (1997) argues that student learning can be enhanced through their participation and engagement in teaching and reflections on the relationship between teaching and learning. Thus, students' mathematical understanding is deepened when they learn about teaching as they learn mathematics. Students are *critical coinvestigators* in teaching and learning (Freire, 1982). Frankenstein's argument is grounded in Freire's (1982) notion of learning and teaching as part of the same process. Further, Frankenstein contends that teaching and learning are different moments in the cycle of gaining existing knowledge, of re-creating that knowledge and thus, producing new knowledge.

About the dialectical relationships among teaching and learning, learning, and understanding, Doll (1993) writes:

Learning and understanding are made (not transmitted) as we dialogue with others

and reflect on what we and they have said--as we "negotiate passages" between ourselves and others, between ourselves and our texts (p.156).

Lappan and Briars (1995) list several characteristics of learning. Three important characteristics they mention are that: 1) learning is contextual; what students learn is fundamentally connected with how they learn it, 2) learning occurs best through dialogue, discussion, and interaction and 3) learners must be actively engaged in the process. Thus, Lappan and Briars would assert that rote memorization does not afford students the opportunity to make sense of the subject material.

Traditionally, students have no voice in the direction of the class (Freire, 1993). That is to say, when students enter the mathematics classroom, the instructor has already determined the following:

- What the students will learn (e.g. functions, word problems, inequalities);
- How students will be evaluated (e.g. unit exams, homework assignments, final exam);
- How many times the students will perform (e.g. 5 exams, 5 homework assignments);
- By what methods the material will be presented (e.g. lecture); and
- From where the material will be obtained (e.g. text).

In the traditional mathematics classroom (pre)determined beginnings and (pre)determined endings afford little room for dialogue, discussion, interaction, feedback, or reflection (Doll, 1993).

As we enter the new millennium, changes are necessary to open up the restrictiveness of the current curriculum structure. Instructors are facilitators in that

process of change. Instructors need not be viewed as the absolute authorities of knowledge and learning. Rather, according to Prevost (1996):

> The authority for learning must reside within the student, whose understanding of mathematical concepts grows through his or her participation in well-chosen activities, in discussion with teachers and fellow students, and through reflection (p.51).

A major shift in ideas about curriculum and instruction may require explanation and rejection of our historical past as classroom traditions are challenged by and replaced with postmodern curriculum approaches. The need for students to learn the three R's arose from a demand for a literate workforce during the Industrial Revolution. A key component to many major changes in our educational systems has arisen from some kind of "revolution", e.g. the Industrial Revolution. As we move into the 21st century perhaps we will find our "revolution" that will bring about the changes necessary to transform our curriculum from its current status. That revolution may be associated with the advent and growth of the internet. Incorporating internet use may be necessary for an evolving curriculum to provide opportunities for meaningful approaches to teaching and learning. Such a transformation may require us to find ways that provide students with opportunities to construct meaning and relevance of mathematics for themselves.

Mathematics curriculum is primarily designed with (pre) determined beginnings and endings. The goal is higher achievement, better grades and finding ***correct*** answers. The primary instructional strategy is the lecture method (Doll, 1993; Barr & Tagg, 1995).

Instructors are viewed as dispensers of pre-packaged knowledge and students as the passive receptors (Doll, 1993). Assessment strategies consist of the typical mathematics exam and possibly assigned textbook problems. Students' grades are usually based on an average of the exam scores and maybe assigned homework problems. Traditionally, this method of assessment allows little room for error on the part of student nor is the assessment process typically a learning opportunity for students.. According to Doll (1993), generally, it reflects more of the student's ability to test than the student's actual learning and understanding of mathematics.

Changing views about teaching and learning have ushered in a new era where many view learning as an individual construction of ideas and concepts about mathematics; where curriculum is student-centered and instructional strategies are tailored so that students have opportunities to learn and make meaning of mathematics for themselves, and where authentic assessment strategies are structured so that the instructor and the student can gain a more comprehensive understanding of the student's progress.

Students' Perspectives

Students own meaning-making efforts are influenced by their beliefs about and past experiences with mathematics. Calculus! College Algebra! Math! These are words that strike fear in the minds of many college students. Students' experiences, past and/or present, with mathematics conjure up negative expectations and feelings. Mathematics is considered the domain of the few and the torment of the many. Many students expect mathematics to be difficult, unyielding, tedious, unmerciful, abstract, obtuse, and irrelevant

because to them it has always been so. Our society has traditionally deified mathematics. Many, in and out the education arena, have accepted the elitist ideas that mathematics is only for a select intellectual few. Many believe and perpetuate the following notions: 1) Some people are born "knowing" mathematics; 2) Boys are smarter in mathematics than girls; 3) Asians are smarter in mathematics than Whites; 4) Whites are smarter in mathematics than non-Asian minorities, particularly African Americans; 5) White males possess the critical, logical, and analytical skills necessary to succeed in mathematics and science courses and degrees programs, while minorities and women do not; and 6) The teacher/instructor is responsible for a student's learning. These notions tend to foster an attitude of complacency or defeatism in many students.

The aforementioned notions are clearly reflected in our traditional knowledge-validation process (Collins, 1991). In the traditional mathematics classroom, instructors talk ***to*** or ***at*** students not ***with*** them. We expect that mathematics must be done a certain way and taught a certain way to be considered valid mathematics (Code, 1991; Collins, 1991). We have clearly defined ***what mathematics is***, ***who can know mathematics***, and ***how*** mathematical knowledge is measured.

Purpose of Study

Current curriculum focus, classroom procedures and social myths about mathematics learning have influenced the way students and teachers interact with each other and with mathematics. What activities in the college mathematics classroom might encourage students and instructors to become actively engaged in dialogue, discussion,

interaction, reflection, and writing about mathematics? How might activities that encourage these interactions impact students' meaning making of, confidence in, and appreciation for mathematics?

Guided by these questions, my purpose for this study is to investigate how an assigned Internet Project, in a Business Calculus course, encourages conversation about mathematics, and helps students construct relevancy to their daily lives by making meaning of Calculus and its applications.

Expectations

One of the expectations for this Internet project is that through researching their particular topic students will begin to dialogue, to question, to converse, to reflect, and to write about mathematics in a way that allows them to construct their own meaning and understanding of mathematics inside and outside the classroom. Another goal is that students can reexamine their old biases, fears, and misconceptions about mathematics and that through this project students are afforded an opportunity to begin to trust their own intellectual capacity to understand, to learn, and to make sense and meaning of mathematics. My hope is that through our conversing, questioning, reflecting, and writing about Calculus students' goals for the course, for mathematics, and for this project will manifest themselves.

Rationale for the Study

As an educator, my desire to change the nature of conversations and meaning making in mathematics classrooms began three years ago. Concerned with the monotony

of my mathematics curriculum as determined by the textbook and my own instructional practices (me lecture-students take notes), I decided to incorporate Internet Projects in my class requirements for Business Calculus. I learned about Internet projects in my graduate mathematics education courses.

Initially, when the project was assigned to my graduate class I was shocked. I thought to myself, "Can you do an *Internet* project in a graduate math course?" Both teacher and student attitudes toward technology influence students' learning and understanding in mathematics courses. The assignment forced me to question my own biases, perceptions and deeply rooted beliefs about what was acceptable and not acceptable in a graduate mathematics course.

Subconsciously, I had accepted the notion that mathematics cannot be fun, and having fun in graduate mathematics classes seemed oxymoronic. Thus, my hope in implementing the Internet Project in the Business Calculus courses I taught was to do something different; something beyond the norm. I wanted students to think, to talk, and to write about the use of Calculus outside the mathematics classroom. I was concerned with students' passive acceptance that I, as their instructor, ***knew*** everything about mathematics and that I was totally responsible for what mathematics they learned and how they learned it. Also, I noted that although I encouraged students to ask questions, some were still reluctant to do so. Others maintained a defeatist or passive stance toward their mathematics learning. As one student commented in class, " It's not you personally, but we don't talk about math, really we just do it...I mean it's not like you're going to use

this anywhere but here [classroom]." Sadly, her statement did not shock me. These same sentiments have been reflected in many conversations I have had with other students and faculty members. Such sentiments indicated to me that some changes were necessary to challenge these ideas. The Internet project challenged my notions of mathematics standards and acceptability. Perhaps it might do the same for other students.

Pilot Experiences with the Internet Project

I implemented the use of Internet projects in my classes about three years ago. I was disturbed by students' passive acceptance of me as the ***dispenser*** of knowledge of Calculus. I wanted students to have an opportunity to find some relevance for themselves. Also, I wanted them to see the uses and applications of Calculus outside the classroom.

Previous Classes

At the beginning of each semester over the past three years, I have asked students to provide basic demographic information about their previous mathematical course experiences. An Internet Project is assigned in addition to more traditional assessments.

To date approximately 135 students (not inclusive of the current study) have completed the Internet Project. The students' ages ranged from 18 to 51 years old. The students' degree plans have included majors in fields from Liberal Arts, Business Administration, Accounting, Economics to Electrical Engineering. These groups of students represented a total of 8 majors. Approximately 72% of the students were female (n=97) and 28 % were male (n=38). Approximately 5% of the students were African -American (n= 7), 7% were Asian-American and/or of Asian descent (n= 9) and 88%

were Caucasian (n= 119). When asked if they had experience writing in any of their previous mathematics courses, relatively few had ever had writing assignments in a college mathematics course. Approximately 68% (n= 92) of the students owned or used a computer and were familiar with the Internet. Others stated they had Internet access on their computers but as of the date of the Internet project had yet to use it. The latter was a group of students older than average and had not used computers because they had "not seen a need to use it." The majority of these students stated that they had bought the computers for their children. Many stated that "back when they were in school" they didn't use a computer and felt intimidated by them. Only 11% (n=15) of the students were familiar with or had used any mathematical software.

The data were collected from informal questionnaires students were asked to complete at the beginning of the course and from class discussions. I used the information to gain further insight into students beliefs about writing in mathematics courses.

The Internet Assignment

Students were assigned to write a two to three page report about an area of interest to them with respect to Business Calculus. The assignment was worth 50pts. I encouraged the students to be creative. The Internet was their sole research source. Basic rules of grammar, punctuation, and citation were to be followed. Students were to locate information pertinent or relevant to their area of study, relate it to Calculus, and state its relevance in the conclusion of their paper. If students found no information relating Calculus to their area of study then they were to state possible reasons in the

conclusion of their paper. Students were also asked to include a brief summary of their experience with the Internet project and how this assignment had influenced or had not influenced their ideas about mathematics, particularly about Calculus.

I tried to keep the project open-ended to allow students more flexibility with the project. Throughout the duration of the project we took class time to discuss students' concerns, questions, and comments about the project.

Pre- Student Responses

Many students in the pilot groups had not written in a mathematics course and at this point saw no reason to do so. I was bombarded with " You want us to ***write*** in a math class!?" I was informed by some students that "You write in an English class, you do math in a math class. You don't mix the two." Furthermore, the idea that they had to do research in a mathematics class was perplexing to some. Some students wondered if it was a ***real*** Business Calculus course. After all the title of the course bears the Calculus name and Calculus is considered abstract, tedious and difficult. An ***Internet*** project sounds "easy." I was surprised to find that many students had not considered the Internet as a tool or resource for finding information about their mathematics.

Although many students found the idea of an Internet project interesting, they still wanted me to tell them what ***I wanted*** them to do. I remember a student who emailed me six times to find out if what she had found was what I wanted. I found that some students were uncomfortable with the idea of using the Internet as a research tool. As students we have been taught that there are acceptable/reliable sources of research information,

traditionally those being journals, books, etc. The Internet has not been used as a trusted source for standard research material as the Internet has few quality control measures. As such, initially, some students found it problematic to use the Internet. Some students wanted to do a research paper. From my informal observations I noted that students were initially fearful of the notion that they could decide the topic and determine for themselves whether or not they felt the information they found was or was not relevant or of high quality. A student commented that, "I am so used to the teacher telling me what to do, that I don't know how to do this." Ultimately, their surprise and resistance seemed grounded in their ideas about mathematics and mathematics classes. What I was asking them to do did not fit with their ideas about mathematics.

Results of the Pilot Experience

Post-Student Responses

Throughout the project we took class time to discuss students' progress. Many students commented that the Internet project was not as easy as they thought it would be. They began to realize that they had to modify and adjust their searches. They had to learn new search strategies to find the information they were looking for. Some students chose to rate mathematics tutorial sites which was an option instead of doing the Internet search in their field. As a result of one rating a student chose to email (not required) the publishing company that maintained the Websites to notify them of the difficulty of the particular site. Some students went so far as to email other friends to notify them of sites that were student friendly and ones were not.

Some students who did not believe that anyone talked about mathematics outside the classroom, found themselves visiting mathematics chat groups and posting questions about Calculus. For example, some students dialogued with others about assignments and differences in their classes. Chat room discussions compared topics of study, nature of assignments and quality of textbooks. Students brought their email to class to discuss with other students in the class.

One student who was an avid race-car driver became exited when he saw an article about inflection points in his favorite magazine. He brought the article to class "to show everyone that Calculus terms are used outside class." He was so excited that he decided to email the company that produced a part he needed to see what Calculus formulas were used in designing the part. He used the Internet to research the part's development. The student also emailed a well-known race-car driver to tell him about the Internet project. The student was surprised when he received a package in the mail from the company detailing the Calculus used in designing the specified part, the historical development of the part, and other Websites related to the specified part's design and development. He also received an email from the race-car driver asking him for more information about the assignment.

The responses from the majority of the students who have completed the Internet assignment have been positive. Their responses were deemed positive because they found that: 1) Calculus is used in everyday life, 2) Calculus is important to their area of study whether directly or indirectly, and 3) the Internet project can help them re-evaluate their

views about mathematics, how they talk about mathematics, and what they believe to be real mathematics. These findings were reflected in the writing of their Internet project papers.

As one student commented, "Maybe we should be thinking about writing a little in math classes. I wouldn't have found out about the free tutorials if I hadn't had this assignment." With regard to writing, a student commented in class discussion that by writing she could find out what it really was she did or didn't like about math. This student also revealed to the class that because she could write about math, she felt she could now talk about math. This was very profound considering this comment came from one of the quieter students in class.

Final Internet Projects for Pilot Groups

The projects were very well done. They were deemed so because of the completed requirements, appearance and design of the final papers. Most students, through their comments in class and on the paper, spent a lot of quality time and effort on the Internet project. However, I noted through my observations that those students who came into the class believing Calculus would be hard and who were more comfortable with being told what to do, found the assignment rather difficult compared to those who saw this, as a student commented, as a chance to "see what they do with this stuff [Calculus]." I also noted that those same students who found the assignment difficult found it so, not because of the requirements, but because it appeared to challenge their notion and beliefs of what mathematics is and what is done in a mathematics class. A

student commented to me that she found this 2 –3 page assignment more difficult than any research project she had done previously because the assignment depended on her using "her own judgment."

With regard to conversation, students seemed to begin to talk more with each other. They began raising questions in class about material on the Internet related to a topic being discussed in class. I found that students appeared to ask more thought-provoking questions. They were making statements such as "What that answer really means is..." Students were trying to apply the material to various real-world situations. Overall the Internet Project appeared to be very beneficial in the Business Calculus courses that I teach. Minor modifications have been made over the past three years. However, the primary focus of the Internet Project has remained intact—to provide students with an opportunity to find relevance and meaning about Calculus for themselves, by providing students with opportunities to discuss, question, reflect, and write about mathematics, and to see applications of mathematics in real-world situations.

Limitations of the Pilot Experience

In the pilot experiences with the Internet project I did not conduct personal interviews with the students nor did I ask them to complete surveys or questionnaires ***after*** they had turned in their completed projects. Primarily, my findings had been based on students' comments in class, from their completed Internet projects and from my personal observations. I had neglected to systematically explore to what extent their ideas about mathematics had changed or whether the project had helped them to make sense of

the material presented in class or to construct their own meanings of Calculus. I wanted to find out from the students, not just from my own observations, if indeed these changes had occurred. Thus, for this study, to gain greater insight from the students' perspectives, I included pre and post questions and personal interviews. The pre and post questions will permit me to discern whether students felt changes had occurred in their ideas about mathematics and to what extent. The interview questions will allow me to have first-hand descriptive data from the students about their experiences with the Internet project and whether they felt the project was helpful to them and in what ways.

Study Framework

I began thinking about my own beliefs that may impact this study by reflecting on my ideas and experiences with mathematics, learning, teaching and meaning making, and working from that standpoint. From those reflections emerged the following questions:

1. What are my expectations for the students in this mathematics class? For all mathematics students in general?
2. What kind of atmosphere am I trying to foster in the classroom?
3. What are my perspectives about teaching and learning? Are these perspectives consistent with my "method" of teaching in the classroom?
4. What is my philosophy of education?

As I began to reflect on my responses to these questions, I found that Constructivism embodied many of the ideas behind my instructional strategies. Constructivism emphasizes learning as more than just a set of observable behaviors

(Fosnot, 1996; Brooks & Brooks, 1993). Students bring with them prior knowledge of mathematics. Constructivism emphasizes making meaningful connections between prior knowledge and new knowledge (Duit, Treagust, & Mansfield, 1996). When students are able to make these kinds of meaningful connections they are able to construct their own meanings of mathematics and not just regurgitate the instructor's or someone else's meanings (Fosnot, 1996; Brooks & Brooks, 1993). Also, when students are presented with opportunities to discuss, question, reflect, negotiate and renegotiate these connections in meaningful contexts with the instructor and other students, they can begin to see not only their meanings of mathematics but others as well (Fosnot, 1996; Duit, Treagust, & Mansfield; Cobb, Wood, & Yackel, 1990).

The framework for this study is also founded on Brooks & Brooks (1993), The Case for Constructivist Classrooms. Brooks & Brooks (1993) discuss characteristics of educational settings that they believe encourage the active construction of meaning in classrooms. One of my expectations in implementing the Internet project in mathematics courses is to provide students with opportunities to construct their own meaning and understanding of Calculus. As such, Brooks & Brooks (1993) discussion is pertinent and relevant to this study. The characteristics of these classroom environments are presented below.

- Curriculum is presented whole to part with emphasis on big concepts.
- Pursuit of student questions is highly valued.
- Students are viewed as thinkers with emerging theories about the world.
- Teachers generally behave in an interactive manner, mediating the environment for students.

- Teachers seek the students' point of view in order to understand students' present conceptions for use in subsequent lessons.
- Assessment of student learning is interwoven with teaching and occurs through teacher observation of students at work and through student exhibitions and portfolios.
- Students primarily work in groups. (p. 17)

Brooks & Brooks (1993) also state that in these kinds of educational settings:

- Students are freed from the dreariness of fact driven curriculums which allows them to focus on larger ideas.
- Students have the exhilarating power to follow trails of interest to make connections, to reformulate ideas, and to reach unique conclusions.
- Students gain the important message that the world is a complex place in which multiple perspectives exist and truth is often a matter of interpretation.
- Learning and the process of assessing learning are, at best messy endeavors. (p. 22)

Many factors influence students' learning, meaning making, and conversation. These influences include classroom atmosphere (Burda & Brooks, 1996;Campbell & Evans, 1997; Canada & Pringle, 1995; Cobb, Wood, & Yackel, 1990; Condravy, Skirboll, & Taylor, 1998; Crawford & MacLeod, 1990; Howard & Henney, 1998; Karanebick & Sharma, 1994; Sandler, Silverberg, & Hall, 1996; Sandler, 1996; Samiullah, 1995; Trice, Naudu, & Lowe, 1996), teacher beliefs regarding teaching and learning (Fasinger, 1997; Stage & Kloosterman, 1995), and students' beliefs about teaching and learning (Haleta,1996; Modell, 1996; Neulip, 1997; Nunn, 1996; Ostergard, 1997).

The dominant view of what teaching and learning are still pervades campuses and classrooms of many colleges (Barr & Tagg, 1995). Students don't ***talk*** about mathematics in the mathematics classroom. They ***do*** mathematics (Andrews, 1996; Lappan & Briars, 1995). Contrary to these norms, research indicates that students learn when they are

actively engaged in discussion about mathematics (Aulls, 1998; Tanner & Casados, 1998; Tate, 1995; West & Pearson, 1994). Research and constructivists ideas about learning suggest students participation in an Internet project may facilitate their meaningful and mindful learning and attitudes about mathematics.

From the constructivist perspective, mathematics classroom environments should foster an atmosphere where both students and teachers are actively engaged in purposeful planning of classroom and course activities. Also, the mathematics classroom should be such that both teachers and students alike are co-investigators in the teaching and learning process; where teaching is not an acknowledgment or perpetuation of well-know facts and symbols, but a development of self through interaction with others (Macintosh, 1990). The mathematics classroom needs to be a place where learning is not simply the stringent, linear, accumulation of facts and theorems to regurgitate on exams. The mathematics classroom needs to be a place where learning is a continuous, transformative process which allows the student multiple ways of learning mathematics (Langer, 1997) and multiple opportunities to converse about mathematics.

Research Question

From these concerns the following research question has emerged:

What will be the impact of students engaged in an Internet project on topics of their choosing related to calculus mathematical topics on:

a) mathematical classroom discourse ?

b) meaning making of calculus concepts?

c) relevancy of Calculus to students' area of study and/or personal interests?

d) students' beliefs about mathematics?

Chapter II

Literature Review

Introduction

Curriculum has been focused in the last decade of the twentieth century on student achievement rather than actual meaning making. The tension between higher standards and meaningful learning has had implications for instruction. Traditionally, mathematics curriculum is structured more for ease of teaching than for students' learning and meaning making. The typical instructional approach has been the lecture method. Assessment of standard mathematics classroom curriculum and subject matter has been through tests, homework, and or standardized exams. Students are generally classified according to their grades not necessarily according to their understanding of the subject matter. An "A "student is one who ***scores*** well on the required assignments whereas a "failing" student is one who does not score well.

Each semester I am required to write a syllabus. I am required to use a textbook adopted by the Textbook Committee. I am required to ***teach*** specific topics considered to be the core requirements for a particular mathematics course. These requirements have not taken into account the students who are affected by them. I remember mentioning to a colleague how interesting it would be to have an experimental course where the students wrote the syllabus, chose the textbook, and chose the core requirements. His response to me was "That's impossible. Students don't understand [mathematics] well enough to do that." Also, lecturing ***to*** students, in the traditional sense, does not require the social

interactions necessary for fostering a learning environment where students can make-meaning of mathematics for themselves. Primarily, standard mathematics curriculum was geared to impart (pre-determined) knowledge with pre-determined endings and correct answers. The standard mathematics curriculum has not been structured to create situations where students and instructors can share mathematics, investigate, question, reflect and dialogue about mathematics.

Pondering the areas of literature that were relevant to this study I choose to conduct a review of the literature in the following areas: 1) Writing Across the Curriculum, 2) Mathematical Discourse (classroom), 3) Students' Beliefs About Mathematics, and 4) The Internet: Computer Uses in Education. All searches were conducted using the standard databases: FirstSearch, InfoTrak/Searchbank, and ERIC as well as the library catalogs of the following universities: The University of Oklahoma, The University of Tulsa, and OSU-Tulsa. A brief review of the literature gathered in each of the aforementioned areas is presented below.

Writing Across the Curriculum

The NCTM Standards encourage the use of writing as a method of teaching mathematics in the classroom to enhance students' learning of mathematics. Researchers have found that writing in mathematics classes enhances students' learning processes (Powell, 1997), and provides teachers with insight into students' understanding (Dougherty, 1996; Freitog, 1997; Norwood & Carter, 1994; Stix, 1994) and into students' thinking in mathematics (Gordon & Macinnis, 1993; Mayer & Hillman, 1996;

Stewart & Chance, 1995).

NCTM Standards also recommend that teachers incorporate writing into their teaching of mathematics as a means of providing students with opportunities to communicate mathematics. However, in a study conducted by Quinn & Wilson (1997) which examined the effectiveness of using writing in teaching mathematics, the results revealed that although most teachers saw writing as an additional tool in aiding students' learning of mathematics most teachers were not using writing in their classroom instruction. Many listed time constraints and students' limited writing skills as reasons for not incorporating more writing to learn activities in their course content. The results of Zerger's (1997) study indicate that most faculty do not clearly distinguish between writing to learn activities and learning to write activities. As such, Zerger (1997) found that a) most faculty assign learning- to- write activities rather than writing-to-learn assignments, b) most faculty view the function of writing as a method of evaluating students while others see it as a way to communicate with students, and c) the definition of good writing varies across the disciplines. The implications for teaching and learning are that although the research indicates that students do learn from writing in their science and mathematics courses many faculty members still do not incorporate meaningful writing assignments into their class curriculum. This occurs despite the fact that researchers have also found that writing in mathematics courses improves students' critical thinking and writing skills (Beall & Trimbur, 1993; Ganguli, 1994; Greene, et.al, 1991; Knudson, 1998; Powell, 1997; Stoecker et. al, 1993). Research studies also indicate that writing in mathematics courses

may affect positive changes in attitudes towards mathematics (Austin, 1998; Hunter, 1995). Researchers have also found that writing exercises can improve students' learning and comprehension of science and mathematics (Hayes, et. al, 1994; MacGregor, 1990; Radmacher & Latosi-Sawin, 1995; Rischel, 1991; Schurle , 1991; Stromberg & Ramanathan; Watkins-Goffman & Dunston, 1994).

Klein (1999) used a 2 X 2 between groups design to analyze the role rhetorical structures play in students learning science through writing. Initially 104 preservice education students observed one of two science demonstrations on buoyancy of forces acting on a stationary object. Three questions were addressed:

1. Does prompting students to adopt planning, production, and revision strategies facilitate the construction of new explanations?
2. Does composing text that includes genre-related rhetorical structures such as argumentation, comparison, explanation, or summary, contribute to explanatory gains?
3. How (i.e through what processes), do these rhetorical structures contribute to students' transformation of specific content during writing (p139)?

Students were asked to a) observe the demonstration; b) write their initial explanation; c) write a journal-style demonstration with or without access to a list of strategy prompts, and d) write their final explanation. Of the original 104 students 85 consented to their writings being used as data for the study. Qualitative analysis of students' writings revealed that during three phases of building explanations (reviewing

experimental trials, analyzing these trials to identify causal variables, and generalizing these analyses to form new explanations), rhetorical structures (explanation, comparison, argumentation, and summarization) did contribute to students' learning. Furthermore, Klein (1999) also found that "these rhetorical structures stimulated, rather than structured the construction of new knowledge (p132)." Thus Klein suggests that teaches may need to construct writing assignments that are more topic specific rather than general knowledge based. Students might benefit more from writing about a specific topic, for example fractions, rather than just say mathematics as a whole. Hunter (1995) had similar findings as Klein (1999). Her ethnographic study indicated that instructors need to decide whether their emphasis is on students' production of proper academic writing or whether the emphasis is on developing their thought processes so that instructors can construct their writing assignments accordingly.

The findings of Mower's (1996) study are indicative of much of the research and still there are a large number of instructors have who have yet to incorporate the use of writing assignments in their mathematics classrooms. Several findings emerged from Mower's (1996) study. They are as follows:

- Writing promoted student comprehension of mathematics.
- Writing facilitated students in making personal meaning of mathematical concepts.
- Writing became a vehicle for dialogue between student and teacher.
- Writing allowed for student reflection regarding the learning of calculus.
- Writing fostered teaching analysis of the rhythms of learning mathematics.

- Writing brought moments of clarity or genius.
- Writings permitted authentic and alternative assessment.
- Writing provided a forum for disclosure for both student and teacher.
- Writing assisted in the development of a community of learners by encouraging classroom discourse. (pp310 – pp319)

According to Mower (1996),

> Writing to learn exercises must be selected with the needs of a particular group of learners in mind. Moreover, the use of writing in this [experimental] college algebra course allowed the student writers to gain ownership (Schulman et al., 1993) of the algebraic content. Writing promotes several critical thinking skills which are fundamental to the learning of any subject.

Although research findings indicated that writing in mathematics courses did help students understand the material and their learning, the literature is still scant regarding the use of writing to learn mathematics activities in college mathematics classes. The use of writing in my study, according to the research presented here, may afford students with an opportunity to learn Calculus, to develop their critical thinking skills with regard to Calculus, and to explore, reflect and construct new ideas about Calculus and relate those new ideas to previously learned ideas about mathematics (Barr, 1995; Mower, 1996; Rauff 1991). This may provide me, as the instructor, with insight into how students are constructing, connecting, and learning mathematics. Writing in this Calculus class may

also help facilitate students in making personal meaning of the Calculus concepts presented.

Writing is also a form of communication and dialogue. By writing in the Calculus class, students are afforded another opportunity in which they can reflectively communicate their beliefs about mathematics with fellow students and with the instructor. Writing is the written communication or discourse about mathematics and according to the research is very important in facilitating students' learning and understanding of mathematics.

Related to writing and meaning-making, verbal communication may also be important in the mathematics classroom. The next section reviews related research in class discourse.

Mathematical Discourse (classroom)

Research suggests that meaningful classroom discourse is crucial to students' initial and continued participation in mathematics courses (Gaskins, et al, 1994; Ostergard, 1997; Tanner & Casados, 1998; Walen, 1994). Observational studies suggest that mathematical discourse grants instructors insight into the multiple ways students construct mathematics and solve problems (Atkins, 1999; Fullerton, 1995). Other research studies support that genuine mathematical conversations can be promoted when students are presented with opportunities to challenge, clarify and justify their ideas about mathematics (Andrews, 1997; Manoucheri & Enderson, 1994; Owen, 1995; Van Zoest & Enyart, 1998).

Of the available research studies related to college mathematics classrooms, most focused on issues such as gender (Canada & Pringle, 1995; Condravy, et al., 1998) , student questioning (West & Pearson, 1994), and student apprehensions (Propenga & Prisbell, 1996) that impacted classroom discourse in mathematics classrooms (Herbert, 1998; Meagher, 1996). However, Nesbitt (1993) proposes the use of group discussions to help students learn mathematics:

> Group discussion also enable students to apply previously learned knowledge to problem-solving situations while receiving feedback from their peers and their teacher and to identify gaps in their own understanding. Because of these significant contributions, classroom discussion needs to be a major part of mathematics instruction, and teachers need to strengthen their competence in guiding this form of classroom discourse. (p.225)

Andrews' (1997) research findings suggest that the authentic give-and-take of talking should be used as a method of fostering pattern recognition, purposeful learning, and pleasure in doing mathematics. Students who are comparing and negotiating ideas as they clarify thinking are engaged in what Owen (1995) calls verbal reflection which requires students and instructors alike to listen to each other.

Much of the research regarding classroom discourse in college mathematics classrooms was rather limited. Relatively few studies explored how the use of research projects in college mathematics courses might foster or encourage classroom discourse. The observational findings of my pilot study indicate the Internet project encouraged

interactive discussions amongst students. Many of the students initially had difficulty in finding information regarding their chosen topics. The students brought their topics to class and discussed amongst themselves possible sites that were useful to their respective projects. They shared their frustrations at the unstableness of Internet sites. They also shared information and ideas on how to search the Internet.

Students' Beliefs About Mathematics

For the most part students' beliefs encompass the notion that mathematics is archaic, hard and only for a select few, and has no relationship to real-world situations. Unfortunately, these beliefs have been engrained in students from a very young age and have been reinforced in many mathematics classrooms. According to the NCTM Standards (1989), "Beliefs exert a powerful influence on students' evaluation of their own ability, on their willingness to engage in mathematical tasks, and on their ultimate mathematical disposition (p. 233)." From the time students are primary age they learn about expected and accepted views about mathematics. Classroom practices reinforce the notion that boys are smarter than girls. Boys are usually called on more than girls. Boys are also encouraged more so than girls to enter the field of mathematics and science. By the time many students enter college their beliefs are firmly in place.

Students' personal experiences with mathematics instructors, peers, mathematics textbooks, and society in general have also helped to shape their beliefs about mathematics. Spangler (1992) suggests that:

> A cyclic relationship appears to exist between beliefs and learning. Students'

learning experiences are likely to contribute to their beliefs about what it means to learn mathematics. In turn their beliefs are likely to influence how they approach new mathematical experiences. (p. 148)

Other researchers have also found that students' beliefs about mathematics effect learning in mathematics (Rector, 1993; Stage & Kloosterman, 1995), their approaches to learning mathematics (Miji & Glencross, 1999) and students' attitudes towards learning mathematics (Kwiatkowski et al., 1993; Miji & Glencross, 1999). Rector (1993) targeted three primary belief categories: 1) Students' beliefs about mathematics as conceptual or procedural, 2) Students beliefs about their own role and the teacher's role in learning mathematics, and 3) student's autonomy with mathematics. In Phase III of Rector's research (Functions Assessment), students participated in three additional interviews which lasted approximately 45 minutes. The purpose of these additional interviews was to investigate the knowledge the students had constructed during their instruction on functions. Each student interview was analyzed as an individual case study. The case studies (n=6) were then cross-compared. The results of the study suggested that students' approaches to solving mathematical problems and their knowledge of functions were consistent with their beliefs about mathematics and their autonomy in respective classes.

Other research indicates that student beliefs about mathematics can greatly influence their receptiveness to change or reform within the mathematics classroom. Walen (1994) conducted a study in which she examined students' views and their own prejudices of their teacher's effort to implement the NCTM Standards into her classroom

instruction and classroom discourse. The participants in this study were fifty-two high school students from two algebra classes taught by the teacher desiring the change. Ten students, five from each class served as key informants for the study. The researcher and the ten students participated in journal exchanges and interviews. The results of the study revealed that participation in the changing classroom environment was influenced by:

a) Student views of the present and future value of the class
b) Student views of what constituted mathematics and how mathematics should be learned
c) A student's perception of general ability, and more specifically mathematical ability
d) Perceptions of algebra as memorized facts, causing them to be resistant to the teachers' efforts to move the classroom dialogue towards an interactive format.

Walen (1994) also found that difficulties arose for both teacher and students with regard to modifying the existing classroom structure, maintaining existing changes during problematic episodes, and with regard to evaluating their progress. Walen (1994) contends that knowledge of students' views of the classroom and learning classroom mathematics is essential for teachers who are desiring to change their existing classroom structure. Walen (1994) writes:

> It is a view of the individual student and that individual's combination of views which mediate their classroom response to change in mathematics instruction which becomes of value to teachers. Teachers awareness of generalities in

student's views and that individuals do not fit in those generalities but view the classroom from idiosyncratic perspectives become primary in this time of reform (p20).

Understanding students beliefs about mathematics is crucial to the success of changes in the mathematics classroom. Knowledge of students' beliefs regarding mathematics is also beneficial to the instructor in that it provides her or him with insight into students' previous experiences with mathematics and expectations for the current class. The relationship between beliefs and instructional practices also suggests the promise of changing students' beliefs through changing classroom interactions and experiences. Having information regarding students' perceived usefulness and relevance of mathematics may help instructors determine how they can use this information to incorporate various instructional strategies and activities to facilitate student learning within the mathematics classroom.

Use of the Internet in Education

Introduction

The Internet has become an integral part of how we interact and communicate in our society. We have integrated the use of Internet technology in our everyday conversations. It is now standard practice to ask for someone's email address before we ask for their telephone number. Many teachers are linking technology with their instruction in ways to create environments where students are actively engaged in their learning process (Bellan & Scheurman, 1998; Iadevaia, 1999; Johnston, 1998; Shively &

Van Fossen, 1999; Tisone-Bartels, 1998; Yirchott & Marquis, 1998). A large number of teachers, however, have not yet tapped into the power of instruction beyond emailing their students. I use the Internet project in my class curriculum as a way to provide students with an opportunity to find relevance and meaning of Calculus for themselves, by providing students with opportunities to discuss, question, reflect, and write about mathematics, and to see applications of mathematics in real-world situations. There are many issues which affect computer usage (McCArthy-Tucker, 1999). Thus, one of my concerns was to find out how college students and other higher-education faculty are using the Internet for teaching and learning inside the classroom (i.e. not distance learning).

Related Studies

Of the available research much has focused on the use of technology as a means of encouraging student interaction and dialogue (Richards, 1994; Shapiro, Rosko, & Cartwight, 1995; Treadway, 1997). Research studies have also focused on the integration of technology (i.e. Internet, computers) into class curriculum (Wells & Anderson, 1995) and the benefits of integrating technology (Kosakowski, 1998). Research studies have also analyzed students and faculty use of the Internet on college and university campuses (Applebee, et. al., 1997; Falba, et. al., 1999; McFadden, 1999; Rumbough, 1999). The results of these studies indicate that students and faculty at the college level use the Internet for personal use, email, and information gathering, which were within school policy guidelines. The findings of Rumbough's (1999) study indicated that although many

of the 611 undergraduates surveyed use the Internet to obtain information related to their education and to their work , they also use the Internet to access sexually explicit material and other non-school related information. Illustrating that on some college campuses the Internet was used very little for "meaningful instruction." However, research also indicated that some instructors were using or desiring to use the Internet to incorporate new teaching methods in the classroom (Battle & Hawkins, 1996; Brown, 1998; Downing & Rath, 1997).

Research by Applebee, et al. (1997) examined the frequency and type of Internet use by academic content area. Their research indicated that "the Internet was being used very little for teaching (p.85)." Other researchers (Johnson & Miller, 1998) have found examples where college faculty were using the Internet to create meaningful instruction in the classroom by providing students with the opportunities to become actively engaged in the process of "integrating new knowledge from the Internet into their existing knowledge" (Sunal, et al., 1998, p.13). Portela's (1999) research findings of a case study incorporating the use of the Internet into classroom instruction revealed that students in the study had a deeper involvement in class activities due to certain Internet links which provided a more meaningful experience for them.

With regard to use of the Internet in the classroom, McDonald , et. al. (1996) found in observations of their case studies, that although many teachers were using technology (e.g. Internet, computer, etc) to "implement their habitual teaching practices," other creative teachers were using the Internet to "play with new pedagogical styles"

(p.107). They also noted that the collected data suggested that the use of the Internet in the classroom is "compatible with the Constructivist teacher role" (p.107).

Summary

The brief literature reviewed here suggests that both written and oral discourse are vital to the success of both students and teachers in the classroom. The research also suggests that although most teachers are aware of the importance of writing in mathematics classes many are still reluctant to incorporate writing in the curriculum. Research also indicates that both students' and teachers' beliefs and attitudes about mathematics, mathematics learning and teaching greatly influence the atmosphere of the classroom and the level of discourse and learning within the classroom. How teachers teach radically affects how students learn. Teachers' pedagogical and epistemological views influence their desire to change their existing classroom structure. These views may also influence their desire or need to incorporate new and innovative teaching strategies in the classroom. Students' beliefs and attitudes influence their desire to learn and their belief that they can learn mathematics and that it can be meaningful to them.

One of the purposes of the Constructivist approach to teaching and learning is for students to be afforded opportunities to connect their prior knowledge to newly constructed knowledge in a way that is meaningful to them. Students need activities in which they can construct their own meaning of the subject material and activities which encourage active constructive mathematical discourse between teachers and students.

Chapter III

METHODOLOGY

Purpose of Study

Current curriculum focus, classroom procedures and social myths about mathematics learning have impacted students and instructors interactions with each other and with mathematics. What activities in the college mathematics classroom might encourage students and instructors to become actively engaged in dialogue, discussion, interaction, reflection, and writing about mathematics? How might activities that encourage these interactions impact student's meaning making, learning of, and appreciation for mathematics? Guided by these questions, my purpose for this study was to investigate how an assigned Internet Project, in a Business Calculus course, encouraged conversation about mathematics, helped students construct relevancy to their daily lives, and helped students to make meaning of Calculus and its applications.

My own beliefs about students' mathematics learning and understanding, as well as my struggles with following a set curriculum and being accountable for the mathematics that my students learn, impact both the questions and the methodology of this study, as well as the purpose or guiding rationale for exploring the potential of integrating Internet use in the college mathematics classroom. The Internet has become and is a vital part of our society. However, with regard to teaching and learning, many college mathematics instructors have yet to utilize the potential of the Internet as an instructional and learning tool in the college mathematics classroom.

Research Question

From these concerns the following research question emerged:

What is the impact of students engaged in an Internet project on topics of their choosing related to calculus mathematical topics, on:

a) mathematical discourse (classroom)?

b) meaning making of calculus concepts?

c) relevancy of Calculus to students' area of study and/or personal interests?

d) students' beliefs about mathematics?

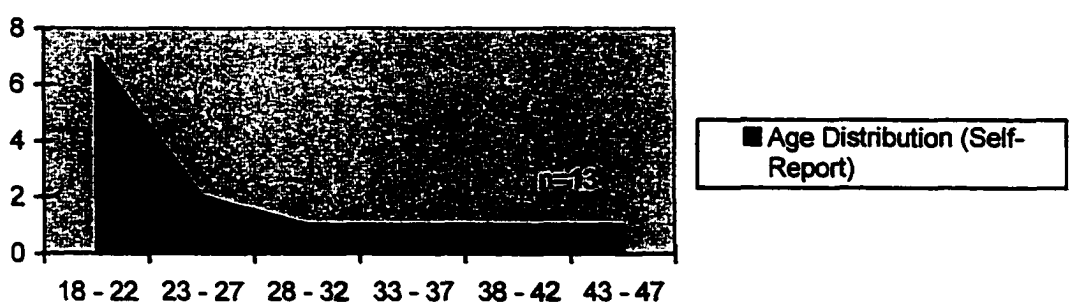
Investigation

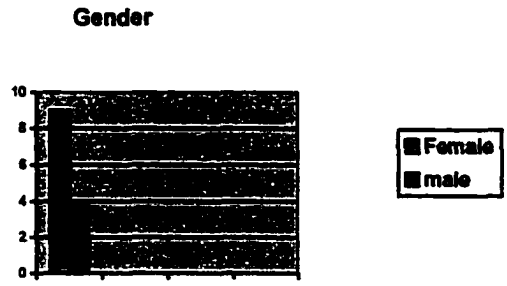
This qualitative study investigated how an assigned Internet research project affected classroom conversations about mathematics and helped students find relevancy of Calculus in their area of study and construct meaning of Calculus concepts in a college mathematics course at a multi-campus community college. This investigation occurred through a modified participant-observation research design. According to Mckernan (1991), "participant observation is the foremost technique for use in the study of class and curriculum (p.63)." This technique permits the researcher to experience the setting or situation being observed from the participants' point of view. According to Marshall & Rossman (1995):

> Participant observation is both an overall approach to inquiry and a data gathering method. Participant observation is to some degree an essential element of all qualitative studies. As its name reveals, participant observation demands first hand involvement in the social world chosen for study. Immersion in the setting allows the researcher to hear, see, and begin to experience reality as the participants do (pp78 –79).

Participants

The convenience sample population for this study consisted of currently enrolled students at a multi-campus urban community college in a Southwestern state. Students enrolled in one section of Business Calculus taught by the investigator were used in this study. The limit size for upper division mathematics courses at this campus was twenty students. There were 14 students enrolled in the selected section of Business Calculus. There were four international students in the classroom representing China, India, Iran, and Nigeria. Each of the students was classified as English proficient according to their scores on the TOEFL. To be considered English proficient enough to enroll in courses at the urban community college used in this study, a student must score an average of 500 or higher on the TOEFL. All of the students (n = 14) in this class brought with them unique mathematical and classroom experiences. Students' ages ranged from 19 years old to 44 years old. Three of the students were "fresh" high school graduates and others were returning after lengthy absences from the formal educational setting. For clarity the age distributions and gender of the class are presented in graph and tabular form below.





Entry

When students enter the classroom not only do they bring their notions and ideas about mathematics, they also bring their beliefs about mathematics instruction and the role of the teacher. At the beginning of the course I took a poll of the number of students who had heard of me prior to the course. Only one student knew me personally. Other students had enrolled in my class because I had been recommended; or, they had heard, by other students and or other faculty members, that I am an "instructor who cares whether students get it". Of the fourteen students in the class seven did not know anything at all about me. All of the students were enrolled in Business Calculus because it was required for their degree plans.

Building Trust in the Class

Building trusting relationships with students begins the first day of class. Body language, verbal language and tone can influence students' trust of and relationship with the instructor (Copper & Simonds, 1999). Telling students to trust you does not necessarily mean that they will. Students need to see consistent action and persistent communication compatible with that action. There need to be situations in class that are empowering to students. Students need to see that they can make comments about mathematics without fear of ridicule and that the comments are valued. I wanted to establish an on-going relationship with the students in this study as I do with all the

students I teach and have taught in the past. Thus to establish trust for the study, I needed to first establish trust in the class. To begin this relationship we established and maintained what I termed " demonstratable patterns of consistency." I used inclusive language in classroom lecture and incorporated discussion and interactions with students in and out the class. We began by discussing basic questions about the syllabus, the textbook and the course itself. We discussed expectations of each other. These expectations included listening to each other. I informed students that "my" strategy of working a problem was not "the" only strategy for working a problem. This was demonstrated in a class session when I was working a problem on the board and a student saw another way to work the problem. She interjected, "Ms. Rose why can't we work it this way?" I told her we could and asked her if she would show us how. After she worked the problem some students found her strategy easier to understand than the method I was using. Students then asked if they could use either method. I informed them that it was up to them. Also, during class we would work the problems according to the different approaches so that students could verify for themselves the equivalency of the multiple strategies, e.g. that the multiple approaches provided the same answer to the problem.

It appeared to me that after the first quiz the students began to really believe that there are multiple strategies or approaches to solving mathematics problems and that one strategy was not necessarily the "right" strategy. Students commented that the material on the quizzes was consistent with the material and the multiple problems solving approaches we had proven and worked in class. One student commented, " You were not trying to trick us." When students saw that they did not loose points for using alternative strategies, they began to be more vocal than at the onset of the class about alternative solution strategies and in general. I encouraged students to ask questions and offer comments. As students began to become

more vocal in class we took class time to discuss their questions and concerns.

At the beginning of the semester I informed the students that the syllabus is a guide to the course but it is also subject to critique and modifications. As the semester progressed students provided the input for the modifications to course work and design. With regard to grading I informed students prior to each quiz where I would deduct points and why. I informed students that I did not give full credit for correct answers and why. I found that by explaining my reasons for my actions and maintaining "demonstratable patterns of consistency" throughout the semester that students appeared to trust what I told them in class. According to the students they felt that I "understood them," they could "talk to me," and that I "really cared."

Building Trust for the Study

Having established "demonstratable patterns of consistency" for an atmosphere of trust and acceptance in the class, I found that when I discussed the study with the students they were very receptive. I asked students at the beginning of the semester if they would complete a questionnaire. Students wanted to know what the questionnaire was for. I explained that it was for my dissertation research. I also informed them that completion of the questionnaire was voluntary and would not influence their grade in the class. I reiterated to students that it was their opinion I wanted. (See Appendix B)

Three weeks later when I administered the questionnaire to students, I wanted to ensure that students' understood that I wanted their "truthful" responses on the questionnaire and in the personal interviews. I assured the students that their responses would remain confidential and that I would not include any distinctive identifying characteristics in my paper. I also assured the students that their participation (or non-participation) in the study would not influence their grade. I verbally assured the students

throughout the semester that I wanted their opinions and that any comment they did make should reflect their viewpoints, not what they felt I wanted to hear. A student then raised the question, "Does it really make a difference?" I used this question as an opportunity for class discussion about accurate data collection and participant responses, citing examples such as the U.S. Census. I then asked the class whether they thought it would make a difference how someone responds to a survey or how the data is reported. One Business student commented that, "Its like reporting your company made a million dollars in sales when it only made $10,000. You're grossly distorting the facts." Another student commented "Someone could invest in a company based on a portfolio that may not reflect the company's true revenue. Which means you could loose a lot of money." Another student said that "It doesn't really reflect what students think. So you can't use it." The information communicated during class discussions was consistent with and corroborated students' written feedback. This contributed to the validity of the findings.

Instruments

The instrument used was designed specifically for this study (see Appendix C). It was comprised of nine open-ended questions. The purpose of the questionnaire was for me to gain an understanding of students views, perceptions and/or feelings about mathematics, and the use of writing and research projects in mathematics classes. The pre-post questionnaire originally had 14 open-ended questions. However after review by students (n=8) and faculty (n=6) not associated with the study the questionnaire was modified to nine questions. I used the peer review process to address issues of trustworthiness, reliability, and validity of the instrument. A brief description of that process and technique are given in the following section.

Content and Construct Analysis

The Questionnaire

When I first constructed the questionnaire, I asked three students to review the 14 questions (clarity, ambiguity, and redundancy). I then asked six full-time faculty members from the Science and Mathematics division of the participating campus to review the 14 questions. These six faculty members had an average of twenty years teaching experience and encompassed four different subject areas in mathematics and science. All of the students and the faculty members found three of the fourteen questions to be ambiguous. The students commented that two other questions appeared to be "asking the same thing" and were redundant. Thus the first three questions were eliminated from the questionnaire and the other two questions were modified and combined to form one question. After the modifications, the faculty members commented that newly revised question appeared to be a "straight yes or no" which seemed to be inconsistent with my open-ended question approach.

To test whether this statement was accurate, I asked the three original students and five other students in the mathematics lab of the participating campus the question. All the students read the question twice. Four students responded with a yes. Three students responded with a no. The last student stated that he did not understand the question. Thus, the question was eliminated from the questionnaire. With regard to spacing, I spaced the questions equal distance apart to ensure students did not perceive one question as more valuable than the other.

After modifications were made to the questionnaire, I asked the six faculty members to review the questionnaire again. The six faculty members indicated that the questions were clear and appropriate for community college students and for finding out

students' opinions or beliefs about mathematics and the related areas presented in the questionnaire.

I then reviewed the questions with the Chair of this study to determine the appropriateness for the sample population of this study and for determining if the questions addressed the issues presented in the study. The questions were reviewed and approved by the Chair and by the Institutional Review Board of the University of Oklahoma.

Interview Questions

I followed similar procedures for constructing the questions for the personal interviews. The three students used in the Pre-Post questionnaire were not associated with the study or with the student-body of the participating campus. The purpose of the Interview questions (See Appendix D) was to provide students with another opportunity to describe their experiences with the Internet project, to explain in greater detail the extent to which they felt the project had helped them make sense of Calculus concepts, to explore how the class had influenced their ideas about mathematics, and to discern whether or not the project had influenced the way they talk or communicate about mathematics.

I asked the same six faculty members to review the interview questions. They indicated that the questions were appropriate for community college students and were appropriate for addressing the stated concerns.

The questions were reviewed and approved by the Chair of this study and by the Institutional Review Board of the University of Oklahoma. (See Appendix E)

Procedures

When students enter the mathematics classroom, they come with their notions and biases of what a mathematics course is like. Because of previous negative experiences, they have already decided in their minds whether or not they will enjoy the course. Students generally do not see mathematics as relevant to their lives or area of study and seldom, if ever, see any real-world applications in their mathematics studies. However, reluctantly, they will take the mathematics course because it is required for their degree program. Many students and instructors alike believe that in mathematics courses students are ***given*** the information needed to do well in the course. Many faculty and students alike have grown comfortable with this arrangement.

To minimize student anxieties about the study, I consistently informed the students the data gathered through questionnaires and interviews would not affect their grade or standing in the course. I informed students throughout the duration of this study that the data collected was confidential. I reiterated to students that the series of questions and interview portion of the study were on a voluntary basis. Students were free to withdraw from participation at any time. Perhaps, more importantly, I got to know each of the students, building a trust and relationship that helped them to know that I really wanted to know what they thought and not what they thought I wanted to hear.

This study was conducted over a six-week period during the Spring semester of 2000. Permission to conduct the study was obtained from the Dean of Instruction and the Division Chairman of the Science and Mathematics Division of the specific campus. Students were asked to complete a series of questions (Appendix C) at the beginning of the semester (approximately three weeks after the beginning of the semester) and again at the end of the six-week period after they had turned in their projects. These questions

were used to gage students' perceptions and/or feelings about mathematics teaching and learning and about researching and writing in mathematics classes. Students were also provided a one-page sheet with the requirements for the Internet Project.

At the end of the six-week period students were asked to participate in personal interviews. To remain consistent with the relationship of trust that I had established with the students I asked them to choose the time they wanted to be interviewed and place of the interview (on campus). During the interviews, students were asked questions (Appendix D) regarding the use of the Internet project as a tool to encourage conversation and interaction in the mathematics classroom. They were asked whether the project was helpful in understanding Calculus concepts presented in the class. They were also asked to respond to questions about their experiences with the Internet project. Their responses were used to address research questions related to meaning making, relevancy, and ideas about mathematics. All responses were audio-taped.

Authorization for this study was obtained from the Institutional Review Board of the University of Oklahoma, the Dean of Instruction of the participating campus of the community college and the Division Chair of the Science and Mathematics Division of the participating campus. Students were assured verbally by the researcher and in writing that all information received would be held confidential. Students were provided with an Informed Consent Form (Appendix B) and a Description of Project Form (Appendix A). As this was a required assignment for the course, students were required to complete the Internet Project. However, students were not required to complete the questionnaire or participate in personal or group interviews. All students were free to withdraw from participation in that portion of the study, with no risk to grade, at any time.

Data Collection

The two methods of data collection used for this study were surveying and interviewing. Data were collected from student response to the Pre-Post Questionnaire (Appendix C), the Interview Questions (Appendix D) and from the examination of students' completed Final Internet Projects. Surveys or questionnaires are an excellent way to obtain information regarding students opinions about mathematics. Interviewing is also essential in the study of students to know how they define the context or situation in which they find themselves (Marshall & Rossman, 1989) which coincides with my desire to gain an understanding of students' beliefs and perceptions of mathematics, about writing in mathematics courses and the incorporation of research projects in the classroom curriculum. According to Seidman (1991), interviewing provides the researcher with access to the context of students' behaviors (as they define it) and thereby provides the researcher with a way of understanding the meaning of students' behavior.

Data Analysis

Qualitative methods were used to analyze the data collected for this study. The results of the data analysis will be presented in Chapter 4. According to Marshall & Rossman (1989), "the process of data analysis involves bringing meaning and insight to the words and acts of the participants in the study" (p. 39). Therefore, I used a thematic analysis of the data collected based on study questions and students' categorical responses. In the personal interviews I also used a thematic analysis to uncover the dominant themes. I examined the kinds of words (positive-negative) and actions students used to explain their ideas or feelings. In each situation I placed all student responses (verbatim) together then examined those responses for commonnalities and differences. This group of students was very specific in their descriptions and consistently used word

such as high, low, fairly, very, and somewhat. These terms were used to categorize student responses on a continuum. Then responses were read again to gain insight into the characteristics of what students defined as somewhat, fairly, or very to determine if students were using these terms interchangeably or as distinctive measurements.

Data were analyzed and coded and categorized by categories that emerged from this analysis. Then the data was analyzed from a broader perspective, that is, what did the data reveal about: a) students' mathematical discourse, b) students' meaning making of calculus concepts, c) relevancy of Calculus to their area of study and/or personal interests, and d) students' beliefs about mathematics.

Chapter IV: Results

Introduction

The purpose of this qualitative study was to investigate how a required Internet project, in a Business Calculus course, encouraged conversations about mathematics and helped students construct relevancy to their daily lives by making meaning of Calculus and its applications.

The research question of this study was "What will be the impact, of students engaged in an Internet project on topics of their choosing related to Calculus mathematical topics on:

a) mathematical classroom discourse

b) meaning making of Calculus concepts

c) relevancy of Calculus to students' area of study and/or personal interests

d) students' beliefs about mathematics.

Data were collected from: 1) Student responses to a 9-item open-ended questionnaire administered at the beginning of the semester and again once they had turned in their completed Internet Projects; 2) Personal interviews conducted at the end of the semester, and 3) Students completed Internet Projects. The results of the analysis of the questionnaire, the interviews, and comments from students' completed Internet projects are presented in the following sections.

Pre-Post Questionnaire

The questionnaire was constructed to find out what students' views were regarding mathematics, writing in mathematics, and researching in mathematics prior to and after the Internet Project. Understanding students' thinking about mathematics and related topics is necessary to discern any potential impact completing the Internet project

may have had. The following is a breakdown of the questions as they pertain to this study.

Question #1: What is mathematics?

This question has been pondered and discussed for hundreds of years. To date no universal definition of mathematics has emerged. By understanding how students define mathematics, we can gain insight into students' beliefs about mathematics. It also can provide us with information into how students may possibly approach solving mathematics problems and what they perceive to be important about mathematics.

Question # 2: How relevant is mathematics to everyday life?

Question # 3: How relevant is mathematics to your area of study? Career goals?

Questions two and three were designed to find out what students' feelings were regarding relevancy of mathematics in everyday life and in their subject area. Answers to this question, pre and post, will help determine the potential impact of the Internet project on their meaning-making efforts by revealing possible changes in how relevant they find mathematics.

Question #4: How do you feel about the use of writing assignments in mathematics courses?

Question #5: How do you feel about the use of research projects in mathematics courses?

Questions four and five were structured to find out whether students saw a connection between writing, mathematics, and their learning of mathematics or whether students viewed mathematics as a separate entity with no relationship what so ever. Changes in responses on the post test may suggest ways writing and research about mathematics may influence meaning making and understanding.

Question #6: When you enter an Italian restaurant you have certain expectations. What do you expect when you enter a mathematics classroom?

Question #7: If you were to talk to a chef at an Italian restaurant you would have certain expectations of her or him. What are your expectations of your mathematics instructors?

Questions six and seven were designed to find out what students expected from the classroom and from the instructor. Many times students and teachers alike enter the classroom with certain expectations of each other. Those expectations can have a lasting impact on how students will or will not conduct themselves in the classroom and with the subject at hand. Changes in the pre-post responses may suggest that the Internet project may impact students' beliefs regarding what is expected in the typical mathematics classroom. Changes in those expectations may impact the way students' view mathematics learning and instruction, perhaps moving from a negative viewpoint to a more positive one.

Question # 8: What are your roles and responsibilities as a student of mathematics?

Question #9: What are the roles and responsibilities of instructors of mathematics?

Questions eight and nine were designed to find out what students believed to be their roles as students and what the believed to be the role of the instructor. Changes in the post responses may suggest that students may begin to have more reliance on their own abilities to learn and understand mathematics rather than sole dependence on the instructor for their learning and understanding of mathematics.

Although questions six through nine might be perceived as identical questions—they are not. Considering one's perceived expectations, roles, and responsibilities may not necessarily materialize into actual reality.

Students were administered the 9-item open ended questionnaire at the beginning of the semester and again after they had turned in their completed Internet projects. The findings of the Pre-Post questionnaire will be presented in the following sections.

Data Analysis and Findings

The Questionnaire

Thirteen students (n=9 female, n=4 male) completed the pre-questionnaire. Eleven students completed the post-questionnaire. The students' ages ranged from 20 to 44. There were five majors represented by this group: Accounting, Business, Computer Science, Law, Mathematics, Physics and Astronomy. The small sample size of 13 –11 students afforded me the opportunity of analyzing the data by hand. Students' responses from the pre and post questionnaire were typed and then arranged according to the specific question. For example pre-post responses to Question #1 were grouped together. I then read and reread student responses and categorized their responses according to the terminology used in meaning of their responses. As this was a small sample size many of the students used the same terms to describe or define particular questions. Thus, those common terms were used to establish the categories. I did this for both pre and post responses. I then examined the pre-post responses from the standpoint of what these responses indicated about students' approaches to solving mathematics problems or mathematics in general.

Question #1—What is Mathematics?(Pre)

Thirteen students responded to this question. The categories used to present the data emerged from their own words. Seven students defined mathematics as a study of numbers, symbols and algebraic formulas in a linear one-dimensional fashion. Five students defined mathematics as either, measurements and calculations and/or simple

problem solving completed by using the basics of mathematics-addition, subtraction, multiplication, and/or division. The other two students described mathematics as a basic tool used to make sense of everything we encounter in life that is measureable and as a tool to measure and make sense of the universe.

Table 1 Pre-Mathematics is...

Numbers, Symbols, and Formulas	Problems Answered by basic calculations	A basic Sense-Making Tool
7	5	2

Question #1—What is Mathematics?(Post)

Prior to the Internet project the majority of students defined mathematics as numbers substituted back into formulas to solve problems. However, after the Internet project of the eleven students who responded to the question "What is mathematics?", nine students had completely different responses. The common link between the different responses was that now these students described mathematics not as a finite process, rather they described mathematics as a study, a search for relationships and applications, and understanding of our world and of the universe.

Whereas before students literally said "Mathematics is numbers and formulas," they were now describing mathematics not only as the study of numbers but the study of the application and relationship of those numbers to everyday life situations. One student wrote, "Mathematics is art and language. Mathematics is a science that allows us to express our understanding of the universe." Another student wrote, "Mathematics is what

we use to make sense of the world. It is how we can manipulate things to accomplish certain order." One student still described mathematics as formulas used to figure out problems.

Table 2 Post-Mathematics is...

A study, a search for relationships and applications, and understanding of our world and of the universe.	Formulas	A Sense – Making Tool
9	1	1

Question #2: ***How relevant is mathematics to everyday life?***

When establishing the categories, once again I consistently used the students' own words. Of the thirteen students who responded to this question six considered mathematics to be very relevant to everyday life. Two described mathematics as being fairly and/or somewhat relevant to everyday life. Five considered mathematics to be important to everyday life. For these five students who did not explicitly use the word relevant but discussed the importance of mathematics in everyday life, one can infer a degree of relevancy from their comments. Therefore, I added another category, "other" to account for their responses. One student cited that although mathematics was relevant in some professions he did not see the need of mathematics use in other professions and I placed his response in the fairly/somewhat relevant category.

Table 3 Pre-How relevant is mathematics to everyday life?

Very Relevant	Other (Important)	Fairly/Somewhat Relevant
6	5	2

Students were able to indicate to a certain degree (ie. very, somewhat, or fairly) whether they thought mathematics was relevant in everyday life. However, most students were unable to elaborate in specific detail. This might indicate that students have been told of mathematics relevancy in everyday life but as of yet were unable to make the connection for themselves.

Table 4 Post-How relevant is mathematics to everyday life? (n=11)

Very Relevant	Relevant	Important
9	1	1

Prior to the Internet project students were able to state whether they thought mathematics was relevant to everyday life but gave limited detail on their reason for so stating. However, after the Internet project students elaborated more in their responses. The students still described mathematics as relevant to everyday life; however their narratives were more descriptive. In some cases the description increased from a single sentence to more specific examples. For example, one student stated that Mathematics is important because it is used everywhere. That same student responded in the post questionnaire that "Mathematics is very relevant to everyday life, in the sense that the daily

fabric of our lives depends upon correct computation of a number of different things e.g. traffic lights (timing), the octane level in gas, marginal analysis e.g. and the profit and loss of a business..."

According to students, the search component of the Internet project provided them with the opportunity to find examples of mathematics use in our day-to-day activities thereby making mathematics more meaningful and relevant to them. A notable difference according to one student was, "Before I knew it was relevant because you're told it is. Now I saw it for myself."

Question #3: How relevant is mathematics to your area of study? Career goals?

Students used the words like **very relevant, fairly relevant**, and **somewhat relevant, and not relevant** to describe the degree of relevancy of mathematics to everyday life and to their area of study. Although students defined mathematics differently from accounting, they tended to use accounting as examples of applications of mathematics to everyday life.

Prior to the Internet project, of the thirteen students who responded to this question, five described mathematics as being extremely (n=1) and/or very relevant (n=4) to their area of study. Three students described mathematics as playing a ***key role*** in their area of study and career goals. I placed those students' responses in the very relevant category. One student described mathematics as relevant. Two other students described mathematics as being somewhat relevant to their area of study and/or career goals. Another student indicated that the only mathematics that was relevant was "financing math." Since the student gave no further elaboration I placed this students' response in somewhat relevant category. Of the thirteen students none indicated that mathematics as a whole is not relevant. The majority of the students in the class were Business majors

(n= 8). Students cited examples such as balancing a checkbook, budgeting, financing a car, and estimation, conversion for dosage calculations, monies, royalties and percentages.

Table 5—(pre) How relevant is mathematics to your area of study/Career goals?

Very Relevant	Relevant	Somewhat Relevant
8	1	2

After the Internet project of the eleven students who responded to this question, seven described mathematics as being very and/or extremely relevant. Three described mathematics as fairly and/or semi-relevant. One student described mathematics as not relevant to his career goals although it was required for his major. Primarily the students commented they were able to find examples which illustrated that in fact that not only was mathematics necessary for their area of study but Calculus was necessary as well e.g. Marginal Analysis.

Table 6 (post) How relevant is mathematics to your area of study/ Career goals?

Very/Extremely Relevant	Fairly/Semi-Relevant	Not Relevant
7	3	1

Question #4: How do you feel about the use of writing assignments in mathematics courses?

Student responses to this question were categorized as: **Good Idea, Not A Good Idea, and Indifferent.** Eight students on the pre-assessment felt that the use of writing assignments in mathematics classes was a good idea. Four students did not think the use of writing assignments was a good idea. One student was indifferent.

Table 7 (pre) How do you feel about the use of writing assignments..?

Good Idea	Not A Good Idea	Indifferent
8	4	1

Regarding the use of writing assignments in mathematics courses most students responded favorably. That is, most students saw the writing assignment as a way to help them understand the mathematics. Others saw it as a possible way of removing the "fear factor" of mathematics. One student saw a writing assignment as a way to make her think. A student writes:

> *"I feel that it is a good idea. A common problem of most great mathematicians is that they are able to compute and conjugate formulas and functions, but are not able to fully explain how they came about the answer. Thus, with writing assignments not only does it enhance a mathematician's communication skills but also expands one's vocabulary (math terms)."*

Another student wrote:

> *I feel that this is a good way to explain a mathematical concept in a unique way. Not everybody is a "number's person," and I feel using these different presentation techniques can have a greater impact on a larger number of people.*

There were two students who believed writing belonged in English course. Another student wrote: *I prefer not to use writing assignments in math. Comp I and Comp II are more than enough for me. Thanks."*

Another student viewed writing as dull and time consuming.

Table 8 (post) How do you feel about the use of writing assignments in..?

Beneficial	Not Beneficial
9	2

After the Internet project, of the eleven students who responded to this question nine responded favorably. One student indicated that although he disliked writing assignments he could see the relevance of using them in mathematics courses. The other student indicated that she believed writing was only necessary if the person were inventing new formulas. However, that would still involve writing about the history of the topic which she did not like. After reading the students' responses I categorized their responses according to how they described their experience with the project. The nine students who responded favorably consistently indicated that the writing assignment component of the Interenet Project was very useful in helping them to understand how mathematics is used in the classroom and in everyday life. Others commented that by writing down their thoughts they were able to "develop different ways of looking at math." Others commented that writing helped them to see what they did and did not know about mathematics. Another student commented that:

> *The writing assignment allowed me to put down on paper what I thought I knew about math. It also helps the teacher understand the student's level of understanding of a given topic.*

With regard to the use of writing assignments in mathematics courses the majority of students saw this as a way of helping them to understand mathematics. They saw it as a way of breaking "the routine of dealing with numbers." One student wrote: "*I feel that they [writing assignments] help the student develop a whole different way of looking at math. It reveals ideas they may not have known or realized before.*" Another student commented that, "*writing assignments can help students reflect on what they have learned.*"

Question #5: How do you feel about the use of research projects in mathematics courses?

Table 9 (pre) How do you feel about the use of research projects in ...?

Good Idea	Not a Good Idea	No Opnion
10	2	1

Prior to the Internet project of the thirteen students who responded to this question ten felt that the use of research projects in mathematics courses would be a good idea. These students indicated that they believed research projects would be a good way to encourage students to think creatively, to peak their interests in mathematics. Others commented that research projects might possibly help students understand their mathematics courses better and to see the relevancy in everyday life. One of the nine who responded favorably also commented that doing a research project was an opportunity for students to "broaden their horizons." Another, student commented that she would "try

anything" that might help math make sense. Two students indicated that they did not think it would be a good idea because mathematics was about numbers and formulas not about writing which they believed to be boring and tedious. Another student indicated that he had no opinion regarding it use.

Table 10 (post) How do you feel about the use of research projects in ...?

Beneficial	Beneficial (w/dislike)	Not Benefical
9	1	1

The majority of the students prior to the Internet project saw the use of research projects as a way of doing something different in mathematics, as another way of helping them to better understand mathematics. So many of the students started the project with the mindset that this was going to help them learn and understand mathematics, particularly Calculus in an innovative way. Eleven students responded to this question once they had turned in their completed projects. Nine of the eleven students indicated that they considered the Internet project beneficial because: a) they were able to explore the realm of mathematics beyond what was in the textbook, b) it [the Internet Project] gave them a new positive perspective towards Calculus and it uses in the "real world," c) it [the Internet Project] made them think and reflect on what they did and did not know about Calculus and what they needed to know, and d) the project was a change of pace from doing just problems and the excitement of learning something new and interesting made math more fun. Thus, their overall opinion was positive. They were able to specify how completing the Internet project was beneficial to their learning and enjoyment of

mathematics. Their emphasis on the ability and opportunity to reflect on their mathematics was note-worthy.

Question #6...What do you expect when you enter a mathematics classroom?

Table 11 (pre/post) What are your expectations when you enter a mathematics classroom?

Physical	Environment	Peer and Group Relationships
• **Chalk** • **Graphboards** • **Projectors** • **Ample lighting and ventilation**	• **Fun** • **Comfortable** • **Challenging** • **Interesting** • **Relaxed atmosphere** • **Conducive for learning difficult mathematics and different ways of doing mathematics**	• **Students with same level of competency** • **Knowledgeable instructors** • **Nice instructors who will explain difficult concepts** • **(pre) Boring and dull instructors who assign lots of tedious and repetitive homework** • **(pre) Instructors who talk "at" you not "with" you**

Thirteen students responded to question #6: "*What are your expectations when you enter a mathematics classroom?*", prior to the Internet project and eleven responded to the question after the Internet project. Their responses were overlapping in such ways that it was difficult to "categorize" them in a standard linear format (e.g. eight of the fourteen said). Therefore, I coded their responses according to pecific kinds of expectations: ***Physical, Environment, Peer and Group Relationships***. Students expected physical items such as plenty of chalk, graph boards, and "things you would only see and use in a math class." Of their peers they expected similar levels of understanding e.g. fellow student competency. That is they expected their fellow classmates to be at the same educational level. One student commented: "*I expect that everyone in the class be on the same level of education and well developed lower skills to be prepared for the current courses.*" Another student wrote: "*Students who are prepared for class in that they at least remember the basic of mathematics.*" Students expected the classroom environment to be fun and comfortable and they expected to see a knowledgeable instructor at the front of the classroom. Some students paralleled their expectations with those of the restaurant. That is they expected a relaxed atmosphere. They expected to have fun in their mathematics classes.

As there were no significant changes in the pre and post students' responses to Question #6 I have grouped the responses together in Table 11. Two notable differences were the student who responded with "Boring dull professors and lots of tedious and repetitive homework" prior to the Internet Project responded differently on the post questionnaire. He responded that he expected instructors to explain mathematics in a way that was fun and interesting. This student reiterated his expectations in class discussions. However, the student who responded with "the instructors who talk "at" you not "with"

you," was de-enrolled from the class on three occasions and chose not to return to the college. As such, the data does not reflect a change in the student's response to question #6.

Question #7 What are your expectations of your mathematics instructors?

Thirteen students responded to this question prior to the Internet project. Many of their expectations were overlapping and could fit into one or all of the categories. Therefore, I categorized students' responses in terms of what kinds of **personal attributes, teaching methods and styles,** and **classroom interactive styles** they expected from their mathematics instructors.

Table 12 (pre) What are your expectations of your mathematics instructors?

Personal Attributes	Teachings Methods and Styles	Classroom Interactive Styles
• Logical thinker • Creative • Sense of humor • Patient • Enthusiastic • Good communication skills	• Teach and explain in ways that all students can understand • Organized lesson plans • Thoroughly knowledgeable about the subject material • Relate mathematical concepts and material to real-life situations	• Inventive • Engaging • Understanding • Creative • Visual boring • Dull with monotone voice • No passion for teaching or their work

Students' expectations of mathematics instructors were that he or she be a logical thinker and knowledgeable in the subject area. Students also expected the instructor to have a sense of humor, to be creative and full of enthusiasm about mathematics. Students expected instructors to teach the material in a way that encompasses their particular diverse learning style. That is, " *they need to know what each student must already know and be able to master. I expect our teachers to answer any questions and explain our concepts so that every student understands.*" Another student wrote: " *To know their stuff. And try to see things from the students perspective, just as if they, the instructor, were having to learn and all from the beginning like the student.*" Students expected their instructors to make the mathematics material relevant to their work or area of study. Students also expected the instructors to have organized lesson plans and handouts (if necessary). The majority of students had positive expectations of their classroom instructors. However one student stated: " I expect a very knowledgeable professor with less than average teaching skills. I expect a professor to talk "at" us not "with" us." This student's response appears to be indicative of much of the research regarding student expectations of their mathematics instructors. This group of students did indicate during many of our class discussions that many of them had had positive experiences with some of their college mathematics instructors. This may account for the shift towards positive expectations despite the contrary findings in much of the research on students' expectations.

Question #7 (post) What are your expectations of your mathematics instructors?

Eleven students responded to this question after the Internet project. Students' responses were overlapping as prior to the Internet project. However, there were significant changes in terms and narratives of students' expectations of their mathematics

instructors. Students were more concerned with instructors' teaching methods and styles as well as instructor's classroom interaction styles.

Table 13 (post) What are your expectations of your mathematics instructors?

Personal Attributes	Teachings Methods and Styles	Classroom Interaction Styles
• Down to earth • Creative • Sense of humor • Patient • Enthusiastic • Good communication skills • Knowledgeable and experienced teacher	• Teach and explain in ways that all students can understand • Organized lesson plans • Encourage different ways of learning math • Relate mathematical concepts and material to real-life situations • Encourage creativity and exploration of mathematics beyond the textbook	• Open and Honest • Engaging • Understanding • Encourage Creativity • Encourage and attitude of questioning • Create and open and free classroom for not only questioning but debate • Caring and helpful • Down to earth and non assuming of student' math abilities-sensitive

Of the mathematics instructor's students expected the instructor to encourage them to explore mathematics, to look beyond just the textbook, and to find what was

hidden. Students also indicated that they wanted instructors to respect them and to be knowledgeable about the subject, but also be sensitive enough to realize students are not as knowledgeable about mathematics as their instructors and therefore be willing to explain each step thoroughly. Students also stated that they expected their instructors to help them find the humor and the beauty of mathematics. One student wrote: " for the instructor to be open and honest about all issues concerning the class. To be available for out of class discussion, to create an open and free atmosphere for not only questions but debate." Students also expected their instructors to show the relevance in the use of mathematics in ways that are easily understood. One student commented: "I would expect experience of a teacher. I would expect human relations skills. Understanding, caring, are all requirements (or should be)." Another student stated that he expected the instructor to be down to earth, and to not assume that students are instilled with math brains.

Question #8: What are your roles and responsibilities as a student of mathematics?

Thirteen students responded to question #8. Their responses are categorized as follows: **Inside the classroom** and **outside the classroom**. With regard to the roles and responsibilities of students, most students cited doing their homework, paying attention in class, not distracting others and studying as some of their more important responsibilities. Most students considered it their responsibility to learn mathematics and to "absorb" the information. Most students felt it was their responsibility to ask questions as well as answer them. One student commented that not only was it her responsibility to become familiar with the material being taught and to learn but it was also her role to help other students. She writes : "My role should be to help whenever necessary because peers help peers better sometimes." Another student added that it was her responsibility to challenge herself and to apply what she had learned to other situations.

Table 14 (pre) What are your roles and responsibilities...?

Inside the classroom	Outside the classroom
• **Attend class** • **Ask questions** • **Be prepared for every class** • **Be respectful of other students** • **Participate** • **Challenge myself** • **To learn** • **Understand and apply what I've learned**	• **Study notes and assignments** • **Do homework** • **Have completed all prior math courses** • **Be respectful of other students** • **To learn** • **Understand and apply what I've learned** • **Help peers**

Eleven students responded to Question #8 after they completed the Internet Project. More emphasis was placed on the things students needed to do inside the classroom to ensure their success in their mathematics courses. There responses were categorized as : **Inside the classroom** and **Outside the classroom**. With regard to student roles and responsibilities in mathematics most students articulated that it was their responsibility to keep an open mind about new ideas, make effort to understand these ideas and to work hard and practice what's learned in class. One student stated that, "As a student, ones role should be to contribute in an interactive classroom for better understanding of the topic. To reach beyond the classroom and apply the ideas learned in

the class." Many of the students indicated that participation, that is their participation was also vital to the " success " of the class. Students also commented that it was their responsibility to ask questions, to turn in their work on time and to be respectful of other members of the class.

Table 15 (post) What are your roles and responsibilities...?

Inside the classroom	Outside the classroom
• Attend class • Ask questions • Be prepared for every class • Be respectful of other students • Participate • Challenge myself • To learn the material • Understand and apply what I've learned • Turn in all assignments on time • Keep an open mind about new ideas • Do well on exams	• Study notes and assignments • Do homework • Practice problems to help understand the concepts • Be respectful of other students • To learn • Understand and apply what I've learned • Be prepared to participate in class and ask questions

Question #9: What are the roles and responsibilities of instructors of mathematics?

Table 16 (pre) The Roles and responsibilities are ...

Inside the classroom	Outside the classroom
• To teach • Create an interest for mathematics • To be attentive students diverse learning styles • Be prepared for every class • Establish a good learning environment • Assign challenging material • Grade unbiasly • Be approachable and accessible • Make sure students understand the material • Return all assignments on time	• Be accessible to students • Grade unbiasly • Be a role model • Be respectful of students

Most of the students indicated the instructor's first responsibility is to teach the material. The students also viewed the instructor's role as that of a facilitator and a role model. Students also felt it was the instructors' responsibility to show relationships of mathematics to everyday life. Other students cited the establishment of a good learning environment, imparting of his or her knowledge to the class, and making sure each student

has an equal chance of making it the highest possible grades in class. Five of the students cited that instructors should have fun teaching the material or " not teach it at all." Teachers should have passion and care for the subject, because if the instructor cares the student will care.

Table 17 (post) The Roles and responsibilities are ...

Inside the classroom	Outside the classroom
• To teach and convey knowledge • Present the mathematics material in creative and interesting ways • Make mathematics fun • To be attentive students diverse learning styles • Encourage problem solving • To provide an atmosphere that makes learning math fun and exciting • Be caring, helpful and encouraging to students • Assign challenging material • Grade unbiasly • Be approachable and accessible • Make sure students understand the material	• Be accessible to students • Be approachable and willing to discuss material outside the classroom • Grade unbiasly • Encourage students to find the connections between mathematics and real-life situations • Encourage problem solving

With regard to the instructor's responsibilities, students described the instructor's role as that of a facilitator. Some students felt that it was the instructor's responsibility to make sure the students saw the connections between mathematics and real world situations while others felt the instructor should make the connection for the students. As one student summarized, "the instructors should present the material in a creative and interesting way and make sure the overall objective is to show how math applies in the "real world."

The pre/post questionnaire, which can also be considered as the "before" and "after," allows me to view the changes that have taken place in students' ideas about mathematics, writing, and researching in mathematics courses, their expectations of their success in the class, and their expectations of the instructor. One might consider this process as a where-they-were and a where-they-are-now.

In pilot experiences many students began their mathematics courses with an intense dislike of the course and of mathematics in general. However, as the class progressed, a majority of the students began to change their outlook on mathematics, on Calculus, and on their expectation of their success in the course. Some students had such a change in perspective that they switched their major area of study to one requiring, in some cases, additional higher level mathematics classes.

However, for the participants in this study, perhaps because of their previous positive experiences with other mathematics instructors, the changes in their responses from the pre-questionnaire to the post-questionnaire were rather subtle.

Interviews

Eleven students participated in the interview portion of the study. The students

were asked four open-ended questions. The interview lasted on average from 20 to 35 minutes. Students chose the location of the interview. My purpose for encouraging students to choose (on campus) was to help them be more comfortable in the interview. The audio taped interviews were transcribed verbatim to maintain the authenticity of the students' voices or words. The four interview questions were:

1. Briefly describe your experience with the Internet Project.
2. Was the Internet Project helpful in making sense of the calculus concepts presented in class?
3. How has the Internet Project influenced your ideas about mathematics? If not please explain.
4. How has the Internet Project influenced the way you converse or talk about mathematics?

The purpose of these questions was to provide students with another opportunity to explain in greater detail the extent to which the Internet Project had influenced their meaning making of Calculus, had influenced their ideas about mathematics, and had influenced how they converse or talk about mathematics in and out of the classroom.

Question #1: Briefly describe your experience with the Internet Project

Students' responses were read individually. Then all students' responses were grouped together in essay format and read from the standpoint of a small paper. I wanted to examine students' viewpoint individually then as a group. From this style of examination of their responses, the following components emerged as descriptions of their experience with the Internet project: Choosing a Topic, The Search for Information, The Writing.

Choosing a Topic

Five of the eleven students who completed the Internet project indicated that they started looking for a topic as soon as the Internet Project assignment was announced in class. Three others indicated they began searching for a topic about a week after the assignment was given. One student indicated that she began thinking about the topic for the assignment when she read about it in the syllabus handed out on the first day of class. Two other students indicated that initially they had thought about just writing on "anything." However, they said they had reconsidered because, 1) Maybe their might be a connection somewhere and 2) they asked other students in class about it and "they were taking it seriously."

An informal poll (e.g. raised hands), taken at the beginning of the semester, of the number of student who had done research projects in math indicated that only one student had done a research project before in a mathematics class. However, she did indicate that the students were given topics to choose from. She indicated that by having to choose your own topic "it was more challenging." Students indicated that by having to choose their own topic they had to think about what they wanted to say, the approach they wanted to take, and try to make sense of it for themselves before they could make it make sense to me.

The topics chosen by this group of students included a variety of subject areas from Business Management, Finance, MIS and Calculus to Virtual Reality and Calculus,

Astrology and Astronomy: what does it really mean?, and Accounting And Calculus: Say it Isn't So.

The Search for Information

All of the eleven students who completed the Internet project indicated that initially the search for information was frustrating. Eight of the students began their search from the broad perspective of "**their topic and Business Calculus**." This approach to searching for information yielded thousands of hits, which in most cases many were class syllabi, degree plans/programs from other educational institutions, and/or exams. Only a miniscule number of hits represented the information they were looking for. One student indicated that because this was the only information she seemed to be able to find that she began looking at what other students were doing in their Business Calculus course. This student stated:

> *Since I kept getting all this information about the classes. I decided to see if any of these classes required students to do research projects. If they [students] had research projects I wanted to know if they [students] had problems trying to find information on their topics.*

This same student later on in the interview stated that after discussions in class with other students, she "figured out" that she needed to narrow her topic. She indicated that once she narrowed her topic down she found "a whole new set of information." Most of the students indicated the same issues, that being their method of searching yielded too much information and yet not the information they were looking for.

Students indicated that the group discussions before class were helpful to them because they were able to get ideas about how to modify and adjust their searches so that they were able to find the information they wanted. Most of the students were unfamiliar with the advanced search options now available in most search engines. Most students were unfamiliar with Boolean logic in searching for information and had lengthy group discussions (student-initiated) on the differences as they saw them between the "regular and/or" and the and/or used in searching for information. Eight of the students did indicate during their interview that prior to the Internet project that they felt that students did not need to know how to search the Internet. They indicated that was what they felt the library was for. However, after their experience with searching they would recommend that their fellow classmates take a class on Internet searching.

A student commented:

> *In the beginning it was really frustrating because I wasn't familiar with how to search on the Internet. I hadn't searched on the Internet before. I didn't know how to type, when to use spaces and quotations. Oh my goodness! And how to use the words "and" and "or." Because I didn't know it was so frustrating. But I was determined to figure it out. I did and it was worth it. In the beginning all I did was email now I can research.*

With regard to interview question #1 most students indicated they all had frustrating experiences initially trying to search the Internet. Many students were familiar with using the Internet for chatting or e-mail but had not considered it as a research tool

and as such when they began to try to locate information on their chosen topic found it difficult to find the information they were looking for. Students indicated the difficulty with trying to combine terms to find information.

The students discussed with each other various sites to search and exchanged many of these sites and addresses with each other. However, most of the students commented that after the initial searches and adjusting their search terms and search strategies they were able to find a plethora of information in their particular fields. Two students indicated that despite their attempts they were unable to find information related to their chosen topics. Students were asked to include their search strategies in their completed Internet projects. My analysis of students' search strategies revealed that for those students who initially had difficulty locating information it was due to:

- the use of too broad categories. For example "chosen topic and Business Calculus."
- lack of understanding of Boolean logic, e.g. and/or
- Non-use of the advanced search option
- Limited understanding of keyword searching, online searching and Internet searching.

Students indicated that the search component of the Internet project was enlightning and positive because they found ways of combing mathematics and terms they had not considered and found other uses of the Internet besides chatting and emailing. A student stated during her interview that:

> *I don't have to wait to apply all those concepts in school. If I want to find out its relationship to something I want to know, the Internet opens up the avenue for any subject. I've got a 24 hour a day expert. The most interesting part was that*

it opened up that I could use the Internet for a whole lot more than what I was using the Internet for.

The Writing

Ten of the students who completed the Internet project indicated that they did not have prior experience with writing in a mathematics course. One student had written a research paper in a previous mathematics course and indicated that it was not an enjoyable experience because she had to give an historical account of mathematics. The student indicted that the whole process was "tedious, dull, and boring." Needless to say this student undertook the writing of this project with the same attitude. She indicated that although it sounded interesting, she believed writing and mathematics to be two separate areas and were not meant to be combined.

In her interview she commented:

Ever since I was a little kid math was math and English was English. They were different. We didn't do math in English and we didn't do English in math. They teach you that in school. So this assignment at first was hard. Because now I had to do something different from what I learned all along, that you can write in a math class. At first I thought, I'll do it because it's part of the grade. Then when I actually sat down to do it, it was like it started to make sense and that was scary. I mean you can write down your thoughts about math. I could see where I was and what I wanted to say about math. Then I started writing about how I felt

about math and that made sense to... Although at first I didn't like having to write, writing can help make things clear even math.

Another student commented:

I thought putting thoughts on paper that was nice because no math teacher ever wants to know your thoughts at all. They're there to teach and they don't want any problems. The only writing you get to do is at the end in that little evaluation thing. So for me I thought this was a great idea.

The majority of the students viewed the writing as different from what they were used to but indicated they were willing to try if it would help them make sense of mathematics, particularly Calculus. Students indicted that somewhere along the way students are taught to fear Calculus and mathematics in general. Students indicted that by writing down their thoughts it helped to relieve that fear and unknown of Calculus. They also indicted that "math teachers" generally do not want to know what students think about mathematics. Thus, this was different from the normal mathematics class and as such treated this assignment as an opportunity to make sense of mathematics, particularly Calculus and as an opportunity to let their voices be heard.

Question #2: Was the project helpful in making sense of the Calculus concepts presented in class?

With regard to Question #2, the majority of students did not use the Internet Project specifically as a way of making sense of concepts presented in class but rather as a

vehicle for finding out how calculus related to their particular interests or area of study. Many of the students use the terms or phrase "finding connections." Although they did find information relating the material we had covered in class their primary goal was to find the connections with everyday life, real-world situations, and connections with their current job and future career interests. Primarily the majority of the students did find that connection and as such found the project very helpful in that regard. Four of the students stated during their interview that it was nice to be able to read some of the articles on the Internet and that they now understand what the terms meant and what was being talked about in the article. Four students indicated that they found the project helpful in making sense of the concepts discussed in class. One student who was interested in finding information about some of the topics discussed in class commented on her excitement at being able to understand an article which discussed uses of integrals and differential equations.

The student stated:

> *The project was helpful in making sense of the things we talked about in class. We talked about differential equations and integrals. When I clicked on one of the subject headings it was a four level class and in the notes it talked about integrals and I thought, "we're doing that in class." And I was so excited. I can understand what it was saying. Oh my goodness! I was so happy. I'm going to keep my notes now, I'm not going to throw them away. Once I saw the words then I understood it all made sense. I know I can do this.*

Question #3: How has the Internet influenced your ideas about Mathematics? If not please explain.

Six students stated that the project had reinforced their ideas about mathematics in that mathematics, particularly Calculus is relevant in the real world. One student commented that:

> *To be able to tie Algebra in with Calculus and Calculus with Finance. And that has been the most fascinating because it shows more of an everyday connection. Because when you think about Calculus you think engineers and high mathematical calculations and things like that. But this project helped to see more of a connection with everyday life.*

Another student stated that:

> *The project kind of reinforced the idea that we really need Calculus and we need math. It broaden my knowledge. Even though I still have a long ways to go. I did gain some things that are going to help me be more open to math. Because I hadn't realized the ways formulas were really necessary or could be applied to real life situations. But they can and I think I have gained a deeper appreciation for math.*

One student who adamantly believed that mathematics was only for special people commented:

> *I think a lot of people think this Calculus and math in general are for geeks. And when you find out that mathematics, Calculus or any type of mathematics is relative to your everyday life it can be shocking. I mean you spend your whole life knowing math doesn't affect me. I'm never going to use it. But we do. I mean think of related rates. The amount of gas per gallon, how much you use, how we*

much need. And marginal analysis, cost, profit, revenue. That's Calculus. I mean it's important. I do this at work and will use this even more when I become a CPA. This project helped me to realize that mathematics, Calculus is not just for geeks, we all are geeks, because we all have to use it and we do use it even when we don't realize it.

Students commented that the vast amount of research helped to reiterate to them that mathematics is used in everyday life. Students indicated that they were constantly told that mathematics is used is everyday life and the Internet project provided them with an opportunity to find this out for themselves. Students also commented that the Internet project reinforced technical aspects that they knew about mathematics and Calculus but the Internet project also helped them to see the "enormous" amount of things they didn't know such as the applicability of Calculus and mathematics to everyday life and real world situations. Also, some students indicated that the project also broaden their horizons in other areas. They described it as gaining insight about the unknowns of mathematics and Calculus.

When asked question #4, Eight of the students stated that prior to the project most of their conversations about mathematics were primarily negative. That is they stated that they knew mathematics was relevant because they were told it was. However, " they still didn't like it." They indicated that there had positive experiences with their previous mathematics instructors, however they still did not like mathematics. They were able to do the "inside class" mathematics, however, they had not had previous positive experiences which helped to illustrate the connections between mathematics and everyday life and/or their particular subject area. Most stated that now when they talk about mathematics they try to illustrate the unknown side of mathematics. One student stated:

I think if I talked about math now it would be more positive. I hated math. I have hated science. And as the years have gone by I realized that especially in the field I'm going into if I want to excel I need to like what I'm doing and do it with enthusiasm and zeal. When you started talking about math to me before I had a negative attitude towards math. But now it would be a much more positive attitude towards math. The Internet project made me see the everyday use of math. I mean I saw it in pharmacy, but here they showed how you needed to know how to calculate the half-life of a microbe or the spreading of a virus and all that. Therefore, for me, it reinforced the everyday use of math. Because, math has always been something archaic.

Another student stated:

This changes everything. I know things like some of these formulas in Calculus and math were found by accident. I would speak up for math now. I can say I did something that showed me that math does work. I would have never written in a math class. This is the first time I have written in a math class. At first, I was like a report in a math class. How do you write about numbers? It really wasn't that bad. You learn so much no matter what subject you write a paper in. This helps you to really know your subject when you write and research about it. The Internet was really helpful. Math is not so bad when you can understand it. I would tell them to write down your thoughts that is the place to start.

One student commented: that he could now give concrete examples of how math is used where as before it was just the word of the textbook. Another student commented that:

Definitely, I have talked about the project with some friends. I have some friends

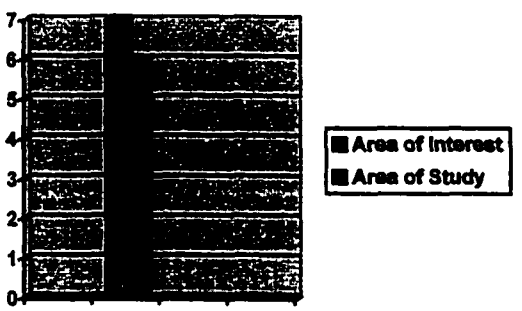
who were in gaming and computer degrees that were doing programming and that kind of stuff. We talked about how it all fits together. I know a lot of mathematical equations and statements are used in programming. So it's definitely broaden my knowledge. It's made a connection between real world and the math in the books.

Students were asked to describe their experience with the Internet project as neutral, positive, or negative. Nine students described the experience as positive, another as neutral as she had previous research experience, and another student indicated that although he learned something from the Internet project he still did not like to write and could not comment either way.

Final Internet Projects

Students were required to write a two to three page report about an area of interest to them indicating the relationship or lack of relationship to Business Calculus. I encouraged students to be creative with regard to design and presentation of the project (e.g. graphics, colors). The Internet was to be their sole research source. Basic rules of grammar, punctuation, and citation were to be followed. Students were to locate relevant literature with regard the topic of their choosing, relate it to Calculus, and state its relevance in the concluding section of their paper. Students who found no information relating Calculus to their area of study were also required to state why in the concluding section of their papers. Students were also asked to include a brief summary of their experiences with the Internet project and include a brief summary on how this assignment had or had not influenced their ideas about mathematics, particularly about Calculus. Students' concerns about the project were addressed in class and via email throughout the duration of the study.

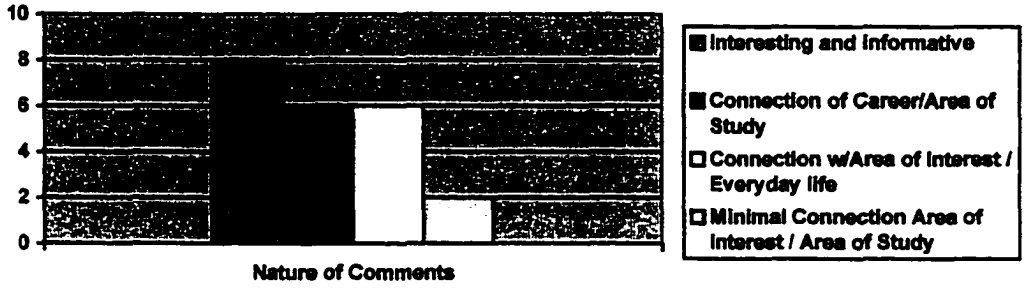
Although I asked students to write only 2-3 pages most students commented that they could not limit their thoughts to 2-3 pages. As such I did not "count off" for more pages that the assignment required. Of the thirteen students who completed the Internet project, seven chose to do the project over a particular area of interest and six chose to do the project over areas related to their majors. Research topics ranged from the standard finance to virtual reality and astrology.



This particular group of students was very concerned with finding their own connections between their topics and calculus. Their concluding comments indicated that they found the Internet project helpful in making connections with real-world and everyday life situations. The shared dialogues regarding frustrating and successful search strategies appears to have encouraged discourse among students in the classroom.

Students were very creative with regard to the design of their projects. Each student to varying degrees incorporated the uses of graphs and illustrations into their projects and also provided description of their reasons for doing so.

Data were analyzed by reading each student's concluding comment from their completed Internet Projects. The summaries were analyzed for emergent commonalities and differences. The commonalities and differences are presented as follows:



The Internet Project can be considered positive for this group of students because, as reported by the students on their questionnaires, interviews, and completed Internet Projects:

1. The process of completing the Internet Project challenged their beliefs regarding writing and researching in the college mathematics classroom.
2. Students were able to find connections between their area of study or interest in a way that was meaningful to them.
3. The Internet project provided students with opportunities to discuss their shared and distinctive experiences with researching for the project.

Chapter V: Discussion

The purpose of this qualitative study was to investigate how an assigned Internet Project, in a Business Calculus course, encouraged conversation about mathematics, and helped students construct relevancy to their daily lives by making meaning of Calculus and its applications. Thus, I began the study with the following research question in mind: What would be the impact, of students engaged in Internet Project on topics of their choosing related to calculus mathematical topics, on:

1. mathematical discourse (classroom)?
2. meaning making of calculus concepts?
3. relevancy of Calculus to their area of interest?
4. student's beliefs about mathematics?

My purpose for part (1) was to examine how the project might impact classroom discourse in that would this project encourage students to become more active in classroom discourse. Data for part one were collected from student responses to Interview Question #4: *How has the Internet project influenced the way you converse or talk about mathematics?*, from student responses to the Pre-Post Questionnaire, from observations and classroom discussions. The analysis of the data collected indicated that students' classroom discourse was primarily impacted by the search component of the Internet Project. Classroom discourse was enhanced by students shared experiences with searching the Internet for information related to their respective topics. Students

commented on question #4 of the interview questions that if they were to engage and when they do engage in conversations about mathematics they do speak differently. They talk of mathematics in a more positive light. They provide more concrete examples of its relevancy and usefulness in everyday situations.

Part (2) of the research question attempted to address the idea of meaning making of calculus concepts. Here, when I use the idea of meaning making, I was considering the idea of making connections, that is students making connections via the Internet Project with ideas of mathematics or material of mathematics they had already learned and students clearly stating so. Students indicated that they were looking for connections and that they wanted to see how mathematics related to everyday life. However, these connections were not connections that were necessarily addressing the previous mathematics they had learned. Students' meaning making efforts were not targeted by, e.g. finding the link between the concepts of increasing and decreasing functions learned in college algebra with those presented in Business Calculus. Rather, their meaning making efforts instead focused on how Calculus impacted area of study and how Calculus impacted possible responsibilities in their chosen area of study. For example one Business Major was concerned with the relationship of her understanding of Marginal Analysis to her desire to become a Certified Public Accountant (CPA).

I found that although students were concerned with making or finding connections between mathematics and everyday life in tne subject, they were primarily concerned with part(3) of the research question. That is, students were determined to find the relevancy

not only of calculus to their area of study or personal interest but the relevancy of mathematics as a whole to their area of study and personal interest. The Internet Project impacted students' beliefs about the relevance of mathematics and particularly Calculus to their area of study and/or personal interest(s). From their own words students described their excitement, and in some cases their disbelief that calculus and mathematics related to their particular area.

When asked most students described this experience as a positive experience. Students reiterated that the previous experience with mathematics had been of the traditional format and did not include research projects or activities. As such, many of the students (n=12) had no prior experiences with writing and or research projects in their mathematics courses. Initially, a few were wary of the idea of writing and/or researching in a mathematics class. Primarily, most of them saw this assignment as an experience in which they could possibly make sense or find connections between mathematics in their everyday lives end or their particular area of study or interest. Students also indicated that they viewed the Internet Project as an opportunity to break from the routine of numbers and formulas.

The students indicated that they found the assignment challenging, interesting and fun. The assignment helped them find material that they might not otherwise have been privy to. Although it reinforced many of the ideas the students had about mathematics (e.g. mathematics is used in real world situations), it also provided them with tangible evidence of mathematics connections to everyday life.

Regarding their ideas of mathematics (Part 4) the Internet Project had a significant impact for this group of students, in that not only did it reinforce their ideas of the relevancy of calculus and/or mathematics to their particular area of study and everyday life, it also broaden their perspective on the uses of the Internet and on how the Internet can be used to find information about various topics. Students also indicated that not only was this project beneficial to their present mathematics class, but they now knew that if they had other mathematics questions the Internet would be a useful tool in finding that information.

Students also indicated that writing and researching in mathematics courses can be used as a way to clarify mathematics topics, but also as a way of helping students to think, to reflect and to write about mathematics in a way that helps them to understand, to find relevancy, and to learn. A student commented to me during the interview that this project has encouraged him to say, "Teachers should try harder to find different ways to help students understand and learn mathematics. It does not always have to be so dreary. How about just trying something different." According to NCTM(2000):

> The need to understand and be able to use mathematics in everyday life and in the workplace has never been greater and will continue to increase. For example: Mathematics for life. Knowing mathematics can be personally satisfying and empowering. The underpinnings of everyday life are increasingly mathematical and technological. For instance, making purchasing decisions, choosing insurance or health plans, and voting knowledgeably all call for quantitative sophistication.

Limitations

There were several limitations to this study. One limitation was the heavy reliance on self-reporting data. This depends on the truthfulness of the students' responses. However, by building and maintaining trust in the classroom students were truthful in that their responses were consistent with their comments made in the classroom.

Another limitation was the sample size. The sample size for this study was comprised of fourteen students. The uniqueness of this group of students may possibly limit generalizations to other classroom and/or students. However, I found the smaller sample size permitted the students to be more comfortable in the class and afforded me the opportunity of giving students individualized attention which is sometimes difficult with larger classes.

Although students in class comments and responses to the survey items indicated they felt the project was relevant and helped them to make their own connections between mathematics and their area of study and/or personal interest, familiarity with the instructor may have influenced their responses. However, an informal survey of students' awareness of me indicated although some had heard about me none had taken any of the other mathematics courses that I taught.

Recommendations for Future Research

Many students commented about the initial frustration with trying to search the Internet for information. I found that many of the students did not know the difference between a search engine, browser, and/or a database. My suggestion to other instructors is

maybe designing assignments which may help students learn the differences and perhaps write a report on the similarities to problem solving approaches.

Classroom Practice

It is not the project itself that makes the difference in a classroom and with students. It is the genuine, sincere recognition and appreciation for student's meaning-making, valuing the importance of students making their own connections, and valuing authentic discourse between students and instructors in the mathematics classroom that can make a difference.

The Internet provides students with access to vast amounts of information in a miniscule amount of time. The Internet is a 24-hour information highway. Students are privy to diverse information, information that can be used in helping them to make their own connections between mathematics and their academic and career endeavors. For those considering implementing projects, such as the ones presented in this study, in their class curriculum, below are some suggestions to consider:

1) Learn about the Internet and the information available to students. Familiarize yourself with research (e.g. current literature, conferences, other instructors) about using the Internet as an instructional tool.
2) For those who are not familiar with the Internet, take introductory search classes offered through many college Continuing education programs and through many community-service agencies.

3) Survey your classes. Find out how familiar students are with writing and researching in mathematics classes. (What kinds of previous research have students conducted? What kinds of writing?) Being privy to this kind of information provides the instructor with insight into some effective ways to construct assignments so that they are meaningful and worthwhile to the students.

4) Construct assignments and weight them so that they **are not** stressful, pressure situations which can often be caused by unbalanced grading (e.g. 75% of the course grade for one assignment). Rather, construct them assignments so that students are encouraged to complete them.

5) "Don't do it, if you don't mean it!" Remember, the task of changing or changing the mathematics classroom is not an easy undertaking. Part of the success depends on the attitude and conviction of the instructor. Students can detect when an instructor is doing something because he or she really means it and really cares rather than just doing something just because it is required.

For this group of students "finding connections" was the key component. They constructed meaning about mathematics and particularly Calculus and its relationship to their area of interest and/or study through the process of researching and writing about their topics. According to Brooks & Brooks (1993) this process of researching and

writing can provide students with opportunities to "make connections, reformulate ideas, to reach unique conclusions (p.22)." These unique conclusions permit students to view multiple perspectives of mathematics and Calculus and from the multiple perspectives understand that many of the "truths" of mathematics are often matters of interpretation. This was illustrated in the classroom when students found that there were multiple strategies or approaches to solving Calculus problems and that those strategies yielded the same answers.

One of my purposes for implementing the Internet project into my classroom curriculum was to provide students with an opportunity to construct their own meaning and understanding of mathematics, particularly Calculus without accepting me as the authority of mathematics. Another reason was to provide students with opportunities to find the connections of mathematics, specifically Calculus to their area of study and/or personal interest. The process of revising search strategies, researching and writing about mathematics helped this group of students to see that Calculus is used in many everyday, "real world" situations whether we are aware or not aware of the uses. It broaden these students perspectives about Calculus and how close it is related to their academic and everyday lives and provided them with tangible evidence to that effect.

When I began this study it was with the position that students might use this assignment as a way to connect mathematical ideas presented in this Business Calculus class with similar concepts previous mathematics classes. For example, students examine how the discussion of increasing and decreasing functions presented here expounded on,

differed from, and/or clarified ideas presented in a previous course, such as College Algebra. Furthermore, students might use those differences and/or similarities to help them gain an understanding and/or construct their own meaning of decreasing and increasing functions. This group of students, though, was primarily concerned with using the Internet Project as a vehicle for finding the connection of Business Calculus to their careers. Despite the differences between approaches of the students and how I anticipated they would approach the Internet Project, the majority of students indicated that they found some of the mathematical ideas of Calculus (e.g. marginal analysis, related rates) were starting to make sense.

If one of the goals of educators is to find ways that students can construct meaning of mathematics for themselves and find the connections and relevancy of mathematics, particularly Calculus then perhaps consider such options which permit students to direct and design the structure of the classroom. What if students wrote the syllabus used for the course? What if students were to design instructional units and present those to the class? That is, what if students were to research and design an instructional unit for example on increasing functions. How would this impact the ways students understand and learn mathematics and construct their own meaning of mathematics? What would happen if students had more legitimate input into the design and instruction of their mathematics classes? Other future research studies might address the following: How might a study of this nature be conducted with larger sections of Calculus (n> 100)? College Algebra? would size influence the students' and the instructor's ability to engage in meaningful

discourse? Meaning-making? How much is the instructor and her/his beliefs important in the successful implementation of any project?

In this study I discussed the integration of technology, the Internet, into the traditional instructional strategies of the class, however consider the impact of integrating the use of the Internet holistically in the class. That is, what if the Internet were used not only as a component of classroom curriculum but as a component of classroom communication (class email) and interaction?

One of the impediments to the questions presented above is the notion of the loss of teacher control in the classroom. However, for the most part students want to participate in activities that permit them opportunities to find the connections between mathematics and the real world. The Internet can be used as an instructional tool and learning tool in the mathematics classroom to encourage student learning, to provide students with the opportunity to make their own connections with mathematics, to find relevancy to their area of study, and to promote classroom discourse. Future research projects might examine the usefulness of Internet projects in remedial mathematics course such as Beginning, Intermediate, and College Algebra. The Internet is integrated into our everyday lives and yet with regard to teaching and learning in many college mathematics classrooms, it remains an untapped resource.

This project provided students with an opportunity to find the relevancy of mathematics for themselves. While this group of students had been told that mathematics was relevant, they had yet to see the relevancy for themselves. Students were able to

realize that writing and researching in a mathematics course can be used as away to make connections between the mathematics in textbooks and in real-world contexts.

This group of students engaged in student-initiated discussions about mathematics and its meanings. Through searching and researching the Internet students were able to see that mathematics is important and state clear reasons why. This group of students gained experiences that were not limited to just this mathematics class, but can be used in all other educational endeavors.

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Appendix A

Description of Study Form

Description of Study
University of Oklahoma
ILAC Department
820 Van Fleet Oval
Collins Hall

Description of Study Form

Title of Project: Impact of An Internet Project On College Mathematics Students' Discourse and Meaning Making

Purpose/Objectives

The purpose of this study is to investigate how a required Internet Project, in a Business Calculus course, encourages conversation about mathematics, helps students construct relevancy to their daily lives, and helps students to make meaning of Calculus and its applications.

Research Protocol

The convenience sample population for this study is students currently enrolled in a selected section of Business Calculus at a multi-campus Southwestern community college. Students will be asked to complete a series of questions at the beginning of the semester and again at the end of the six-week period after they have turned in their completed Internet Projects. Students will also be asked to participate in
These questions will be used to gage students' perceptions and/or feelings about researching and writing in the mathematics classroom, and about communication in the mathematics classroom before and after the Internet Project.
This study will be conducted during the Spring Semester of 2000. Data gathering will be conducted over a six-week period. At the end of the six-week period students will be asked to participate in personal interviews. During the personal interviews students will be asked questions regarding the use of the Internet Project as a tool to encourage conversation and meaning making in the mathematics classroom, was the project helpful in understanding X? How would they describe the experience? Personal student interviews will take approximately 30 - 45 minutes and will be tape-recorded.

Confidentiality

To ensure confidentiality, students' names and personal information and tapes will be stored in a locked file cabinet in the office of the principal investigator. Only the principal investigator will have access to the file cabinet and the keys. However, for the purpose of this study only the student's age, race and gender, responses to the series of questions, responses in the personal interviews, my reflective journals, and their completed Internet Projects will be used in gathering data for this study. After one year all information will be shredded and tapes will be destroyed.

Benefits

The results of this study will contribute to existing research addressing the needs of community college students with regard to nurturing conversation and meaning making in college mathematics courses.

Risks

There are no risks involved for the student. Participation in the series of questions and personal interview portion of this study is voluntary. The student can choose not participate in those portions of the study with no risk to grade.

Thank you for your participation in this study.

Jacquinita A. Rose
Principal Investigator

Appendix B
Informed Student Consent Form

University of Oklahoma
ILAC Department
820 Van Fleet Oval
Collins Hall

INFORMED CONSENT FORM

For research being conducted under the auspices of the University of Oklahoma.

Title of Project: Impact of An Internet Project On College Mathematics Students' Discourse and Meaning Making

You are invited to participate in a study about conversation and meaning making in college mathematics courses. I am a doctoral student at the University of Oklahoma, College of Education, and this study is conducted as part of my dissertation research under the auspices of the University of Oklahoma. The purpose of this study is to investigate how a required Internet Project, in a Business Calculus course, encourages conversation about mathematics, helps students construct relevancy to their daily lives, and helps students to make meaning of Calculus and its applications.

This study consists of a series of questions which you will be asked to complete at the beginning of the semester and again at the end of the six-week period when you turn in your in your Internet project. Also, you will be asked to participate in a personal interview. If you are willing to participate in this study and in the personal interview please sign and date below. Please complete the attached series of questions and return them to me when you have finished. There are no right or wrong answers to these questions. The questions will require approximately 30-40 minutes of your time. To ensure confidentiality, please do not write your name or student ID number on the form.

There is no **risk** to the student. Participation in the questionnaire and interview portion of this study is voluntary and will not influence your grade in this course. By signing below you have indicated and exercised: 1) Your willingness to participate in the series of question portion of this study,
2) Your willingness to participate in the personal interview, and 3) Your consent to have your responses used for the purpose of this study. You may withdraw from participation in this study at any time without penalty.

If you have any questions regarding this study you may contact:

Jacquinita Rose or **Dr. Jayne Fleener**
Principal Investigator 405-325-1081
918-595-7154

If you have any questions regarding your rights as a participant in this study you may contact: **the Office of Research Administration at 405-325-4757.**

I understand that I must be 18 years of age or older to participate.

Name:_____ Signature:_____ Date:_____

Thank you for your participation in this study.

Jacquinita A. Rose
Principal Investigator

Appendix C

Pre-Post Internet Project Questions

Directions: Please do not write your name or student ID number on this form. Briefly answer the following questions. Please write neatly so that I may be able to properly read your responses. Remember there are no right or wrong answers to these questions. Please answer the questions according to **your** belief and/or feelings.

Pre-Post Questions

1. What is mathematics?

2. How relevant is mathematics to everyday life?

3. How relevant is mathematics to your area of study? Career goals?

4. How do you feel about the use of writing assignments in mathematics courses?

5. How do you feel about the use of research projects in mathematics courses?

6. When you enter an Italian restaurant you have certain expectations. What do you expect when you enter a mathematics classroom?

7. If you were to talk to a chef at an Italian restaurant you would have certain expectations of her or him. What are your expectations of your mathematics instructors?

8. What are your roles and responsibilities as a student of mathematics?

9. What are the roles and responsibilities of instructors of mathematics?

Appendix D

Interview Questions

Interview Questions

1. Briefly describe your experience with the Internet Project?

2. Was the Internet project helpful in making sense of the Calculus concepts presented in the class?

3. How has the Internet project influenced your ideas about mathematics? If not, please explain.

4. How has the Internet project influenced the way you converse or talk about mathematics?

Appendix E
IRB Approval Letter