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Metacognition and its effect on learning high school calculus

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METACOGNITION AND ITS EFFECT ON LEARNING HIGH SCHOOL CALCULUS

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ABSTRACT

The following paper discusses the effect of metacognitive training sessions on students' calculus retention. Students in two high school classes participated. The students in both classes were then given lessons on a chapter without metacognitive training and lessons on a subsequent chapter with training in a set of metacognitive skills. After the latter chapter students scored higher on a post-test and expressed desire to incorporate the skills they learned into their other classes.

INTRODUCTION

Training in metacognitive skills such as planning a course of action, selecting strategies, monitoring, evaluating, and revising supports students in developing a deeper understanding of mathematics (Lester, Garofalo, 1985). School mathematics today is results driven, content focused, and fact-based due to the ever-increasing demands of standardized tests. Unfortunately this leads to students who expect teachers to provide them with methods and answers, discourages them from discovering the methods and answers on their own (Schoenfeld, 1992), and leaves them in a passive role. It is important for students to understand that “mathematics is a living subject which seeks to understand patterns that permeate both the world around us and the mind within us” (National Research Council, 1989). Encouraging students to use metacognitive skills guides them away from the passive role and into the engaged and exciting world of mathematics.

I teach small calculus classes at an elite private school. Nonetheless, I still find students who are unable to make the deep connections necessary for higher-level mathematics. In my school the students are often expected to show they can memorize a topic, but not explain the deeper meaning of the topic. This is due, I suspect, to the heavy focus on standardized multiple choice testing, especially the ACT. When asking my students why they had solved a problem using the method they had, I was told, “I do not know.” Students were telling me they did not know why they were doing what they were doing in math class and that they did not know how they arrived at their answers. The students had become so accustomed to their passive role that instead of their first instinct being to question and think, their first instinct was to wait for you to think for them.

After I learned of the power of metacognitive training I was hopeful that it could help my students develop a deeper understanding of how to learn mathematics and what it means to think mathematically.

In the first chapter of this paper, I will review what is known about metacognition and how it applies to teaching high school mathematics. I will describe what the literature says about how using metacognitive training may help my students develop a better understanding of the mathematics they are being taught. I will also report on previous MNS thesis that have focused on aspects of metacognition in their research, and I will describe the works of LSU professor Dr. Saundra McGuire whose academic focus has been metacognitive training. Through these sources I was able to devise a set of activities to help my students develop metacognitive awareness. I will end the chapter by describing what I believe to be some of the most important reasons for my students' problems in calculus, and I describe why the training I devise might be expected to offer a solution.

The second chapter of the thesis will describe a study I used in the classroom in detail. The third chapter will be a presentation of the data, including the data from the pre- and post-tests showing content knowledge gained as well as the data from the surveys regarding students' attitudes and motivation changes about mathematics. The fourth chapter will be my analysis of the impact of the research. The final chapter is the conclusion chapter, where I will discuss my final thoughts on the research and suggestions for further research.

Much of the motivation for this work is based on a set of hypotheses I have about learning calculus. When students arrive in a calculus class, they are often caught off

guard and quickly get lost. Earlier courses have been filled with problems not requiring reference to previously learned concepts. A deep understanding of math is often missing. Calculus is quite often the first course in which each problem requires coordinating large portions math that should be solidly in the student's repertoire.

Solving a calculus problem is like walking down a path in your brain-collecting math you have learned and applying it to the problem as you walk towards the solution. The problem that students face is that they cannot remember where they stored their previous math knowledge, and they get lost along the way to the answer. Students have various reactions when this happens. They may say they never learned any of this before and do not know how to solve the problem. Some students may believe the reason they fail is because they are not capable of learning math. In any case, students will not be able to find success in a calculus course without knowing how to analyze and evaluate problems and address the issues of self-image that might arise.

To bridge the calculus gap, students must develop an appropriate self-identity and adequate self- knowledge. These allow them to take ownership in what they are learning and move from a passive role in the classroom to an active role. The second step is teaching the students to self regulate as they learn, so they can execute plans as they solve problems. The third step is to teach the students to self-assess as they work, change plans as needed, and evaluate their success.

CHAPTER ONE: LITERTURE REVIEW

1.1. Introduction

How to teach mathematics has been highly researched and debated for decades, and many methods have been touted as "the way." Many theories begin with the idea that students already know how to learn. In 1976, John Flavell began researching of how people understand and control their own learning processes, and his work became the foundation for much educational research on metacognition. Before we can address the question of how we ought to teach mathematics, we must address how students learn mathematics (Flavell 1976)

1.2. What is Metacognition?

Researchers who have studied how to improve students' mathematical understanding and problem solving skills have found that, "doing mathematics requires not only a knowledge of rules, facts, and principles, but also an understanding of when and how to use that knowledge" (Boekaerts, Seegers, Vermeer, 1995). The classical definition of metacognition comes from Flavell's seminal 1976 paper:

> "Metacognition" refers to one's knowledge concerning one's own cognitive processes and products or anything related to them, e.g., the learning relevant properties of information or data…. Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects on which they bear, usually in the service of some concrete goal or objective.

In concise terms, metacognition "involves both conscious awareness and the conscious regulation of one's learning" (Wilson, Bai, 2010). Research has consistently shown that

metacognition is a key factor to successful learning. Strong metacognitive skills include a knowledge base of one's own thought process, and regulation and monitoring of one's activity during problem solving. (Lester, 1994) Today metacognition is also understood to include knowledge of one's enduring cognitive traits, as well as the ability to monitor and control current activities.

1.3. Parts of Metacognition

Metacognition was originally split into two main components: metacognitive knowledge and metacognitive regulation (Flavell 1987). Metacognitive knowledge refers to one's understanding of their cognition. Metacognitive regulation refers to one's ability to control one's cognition, which includes assessing work as it is completed it and evaluating your work upon completion.

Self-knowledge (awareness of one's own habits and dispositions) is an aspect of metacognition. We now understand that "students who know their own strengths and weaknesses can adjust their own cognition and thinking to be more adaptive to diverse tasks and, thus, facilitate learning" (Pintrich, 2002). Students who feel over- or under-confident about a subject are far less likely to review and work extra problems, than students who are aware of their level of knowledge. When students have misdiagnosed their level of understanding, it can lead to very poor performance and deep disappointment. Students who thought the classes were easy are often "shocked" at how hard the test is because they did not truly gain understanding. Research has shown that the more accurate a student's assessment of their knowledge, the better their academic performances (Miller, Geraci, 2010).

The beliefs and attitudes a student holds about learning have an ever-present impact on their learning. Knowledge also includes beliefs, whether factual or not, and beliefs are often intertwined with confidence and motivation, which can have great impacts on a student's performance (Lester,Garofalo, 1985). Students have mental representations of themselves and what they can achieve. These representations are their "possible selves." Schoenfeld theorizes that "the idea considered here is that the cognitive behaviors…are shaped by, a broad social- cognitive and metacognitive matrix. That is, the tangible cognitive actions that we observe are often the result of consciously or unconsciously held beliefs about (a) the task at hand, (b) the social environment within which the task takes place, and (c) the individual problem solver's perception of self and his or her relation to the task and the environment" (Schoenfeld, 1982). A key characteristic of a self-aware learner is that he/she holds the belief that hard work leads to success. "They [are] focused on enhancing their knowledge and understanding of an area and on developing competence" (Coutinho,Newman, 2008).

Stigler and Perry reported that the beliefs a student holds about mathematics have a strong correlation with the beliefs their country has. There are large cultural differences in the beliefs held by parents, teachers and children about the nature of mathematics learning. Those in the US tend to assume that understanding is equivalent to sudden insight, whereas, in Japan and China understanding is conceived as a more gradual process (Stigler & Perry, 1989). These beliefs in turn affect a student's actions and can shape what a student perceives as the goal of the activity.

In order to alter student beliefs and misconceptions, teachers must first make the students aware of their beliefs and misconceptions. Students "can only act upon the

beliefs they are aware of… students who are aware that they can monitor and assess their own cognitive strategies can, then, serve as active agents in their own growth. Making students aware of their own beliefs may be one of the most valuable functions we can perform as educators" (Schoenfeld, 1982).

Self-regulation and self-evaluation are often referred to as metacognitive awareness. Research indicates that metacognitive awareness allows for students to "(a) execute a sequence of strategies, (b) employ a set of heuristic that lead to success on a task, and (c) explicitly self- regulate one's behavior in the midst of performing complex tasks" (Hennessy 1999). However, research also shows that unless students are taught how to use their metacognitive abilities, they are unlikely to develop the metacognitive skills on their own. Hence, it is important to continue research on how to incorporate metacognitive training into current teaching (Gama, p. 669).

1.4. Relevance to Learning

Teaching metacognition to students requires that teachers have a pedagogical understanding of metacognition. "Pedagogical understanding refers to teachers' knowledge regarding effective instruction for helping students achieve a goal" (Wilson, Bai, 2010). Once a teacher has a deep understanding of the different metacognitive skills and strategies, he/she can then show the students "what the strategies are, how to implement them, and under what conditions to implement them" (Wilson, Bai, 2010). How the teacher implements this is of great importance in shaping what a class thinks mathematics is and this in turn "will shape the kinds of mathematical environments one

creates—and thus the kinds of mathematical understandings that one's students will develop" (Schoenfeld, 1992).

Lester makes the following suggestions for teachers who are attempting to include metacognitive strategies:

1. Effective metacognitive activity during problem solving requires not only knowing what and when to monitor, but also how to monitor.
2. Teaching students to be more aware of their cognitions and better monitors of their problem- solving actions should take place in the context of learning specific mathematics concepts and techniques.
3. The development of healthy metacognitive skills is difficult and often requires "unlearning" inappropriate metacognitive behaviors developed through previous experiences.

(Lester, 1994)

It is important for teachers to understand that learning to teach with metacognition "will develop slowly overtime, much in the same way that other mathematical ideas are known to develop. (Lester, 1994).

1.5. Relevance to Mathematics

Despite decades of research indicating the advantage of metacognitive training in the classroom, few teachers know how to implement metacognitive strategies that are optimal for the content they teach. Metacognition is not a simply a list of skills to be taught to your students, but teaching an understanding of what it means to think and learn. As Resnick states, mathematics education should be less an instructional process and more a socialization process where students develop points of view and behavior patterns associated with mathematics. Modern classrooms focus mainly on concrete 'mastering' factual knowledge leaving little room to develop understanding of thinking and learning. It is important for a teacher to understand that "being trained in the use of [mathematical]

tools no more means that one thinks mathematically than knowing how to use shop tools makes one a craftsman. Learning to think mathematically means (a) developing a mathematical point of view—valuing the process of mathematization and abstraction and having the predilection to apply them, and (b) developing competence with the tools of the trade, and using those tools in the service of the goal of understanding structure mathematical sense-making" (Schoenfeld, 1992).

When students reach this level of understanding, they will have the capability to interpret data they encounter on a daily basis; they will be able to use mathematics in practical ways, from simple recipes to complex budget proposals; they will be flexible thinkers with a broad repertoire of techniques and perspectives for dealing with problems and situations. A true mathematical thinker will not only seek to understand mathematical facts, but will see mathematics as an evolving science, and will "recognize that mathematics is really a science about patterns and not merely about numbers" (National Research Council, 1989).

While most students are interested in effective performance, they often do not know the best strategies to achieve this goal. As Frederick Reif of MIT states, "They often try to achieve it by resorting to previously learned procedures that specify a sequence of steps, [and] … often lack the ability to extend their knowledge by appropriate inferences from it" (Reif, 2008). Quite often students are taught "mindless procedures, that [they] use (like robots) without any understanding of how or why they work" (Reif, 2008). Reif believes there are three easy steps to remedy this problem. First, teach the students to decide what to do. Second, teach the students how to implement the decision. And third, teach them how to assess whether the decision has been effective. It

is important that students are taught to couple these procedures with the content they are learning.

Not only does a student need to make decisions in class, they need to learn how to organize their information as they learn. How a student organizes knowledge will affect how much of the knowledge students can remember. "Poorly organized knowledge cannot readily be remembered or used" (Reif, 2008). The knowledge of inexperienced students is often rather fragmentary and poorly organized, consisting of concepts and ideas only loosely related to each other. Their fragmented knowledge can easily lead students to misapplications and is also not readily remembered after significant periods of time. If a student can change the way they organize their learning it greatly facilitates the ease with which knowledge can be remembered and appropriately retrieved" (Reif, 2008). Metacognition not only allows for students to understand strategies used to solve the problem, but supports reflection as one solves a problem and enables adjustments in strategy as necessary.

1.6. Problem Solving

Problem- solving receives a lot of attention in the mathematics education literature. "It is safe to say that … problem solving has been the most written about, but possibly least understood, topic in the mathematics curriculum in the Unites States" (Lester, 1994). To first understand the challenges students and teachers face with problem solving, one must ask, "What makes a problem difficult for a student?" (Lester, 1994)? This can be addressed by looking at what skills a good problem solver has and what skills a poor problem solver has.

1. Good problem solvers know more than poor problem solvers and what they know, they know differently—their knowledge is well connected and composed of rich schemata.
2. Good problem solvers tend to focus their attention on structural features of problems, poor problem solvers on surface features.
3. Good problem solvers are more aware than poor problem solvers of their strengths and weaknesses as problem solvers.
4. Good problem solvers are better than poor problem solvers at monitoring and regulating their problem solving efforts.
5. Good Problem solvers tend to be less concerned than poor problem solvers about obtaining "elegant" solutions to problems.

(Lester, 1994)

In essence a "good problem solver" has strong metacognitive skills and awareness. Encouraging teachers to extend their teaching to include metacognitive training would encourage students to become stronger problem solvers and in turn stronger mathematicians.

1.7. Past MNS Theses

The MNS program at LSU has existed since the 1960s. Recently, candidates in the math-teacher track of the MNS have been developing action - research master's theses on classroom problems. Many candidates have incorporated different aspects of metacognition into their research. Some have been assisting LSU Professor Dr. Saundra McGuire, whose work concerns metacognition in the university classroom.

One way to encourage metacognition in the classroom is self-assessment. In his 2009 thesis (Hotard 2009), Daniel Hotard used rubrics as a form of self-assessment in middle school. He attempted to answer the question, "Does the use of self-assessment enhance the short-term learning gains of students in mathematics, as measured by standardized multiple-choice and constructed-response tests?" He faced the problem of students who had lost concern with understanding and focused solely on attaining a

passing grade. He hoped that by using a rubric for self-grading with the problems worked in class, the students would become more invested in the work. Unfortunately he found no significant difference in performance and understanding between the groups who used rubrics and those that did not. He attributed this to poor student attendance, not enough time to fully explore the rubrics, and lack of student motivation. It is also possible that his choice of rubric was not the most effective for self-assessment. Using a scoring rubric may help students understand how a problem is graded, but will not necessarily guide them as they go.

Terry Armstrong (Armstrong 2013) studied self-assessment in high school. Armstrong had students work on word problems using a guide that doubled as a rubric for self and peer- assessment. He used the rubrics not only for a tool to help students understand what they should be doing, but also as a tool for motivation. He allowed the students to compare their work to the teacher's as well as their peers'. He hypothesized this would help them determine the quality of their work independently. He ran a controlled experiment and showed that students who used his rubrics had greater learning gains through his self-assessment than the students who used an equal amount of time to work practice problems.

Another aspect of metacognition is reflection. Underwood (Underwood, 2012) conducted research on student assessment and reflection through the implementation of learning logs. He gave the students multiple choice questions related to the lesson and gave them the option of whether or not to reflect after answering each question. His data showed that using learning logs had no significant effect on the students' knowledge retention. On further investigation, he found that in aggregate the students used only 51

out of a total of 2,020 opportunities for reflection. He drew the conclusion that learning logs assigned under conditions similar to his experiment, would not impact student knowledge retention. Based on this and other evidence Underwood argued that teachers' content knowledge and teaching methodology might be more productive lines of investigations than learning logs.

Dr. Saundra McGuire has been researching with and implementing training in metacognitive strategies at the LSU Center for Academic Success. She has had strong positive results. Dr. McGuire's successful program teaches students metacognitive skills to improve their content learning. It takes students through four key strategies. The first addresses the question "how do I learn?" The second addresses, how to get organized. The third addresses, how to reflect and regulate your learning. And lastly it addresses, how to reduce stress. Using this model of proven success teachers can develop strong metacognitive skills in their classroom as well.

CHAPTER TWO: METHODS

2.1. Introduction

This study involved 27 students ranging in age from 17 to 18 in two separate senior calculus classes in a private religious high school. There were 10 boys and 21 girls, 5 African American students, 1 Middle Eastern student, and 25 Caucasian students. It was the first time any of the students had taken a calculus course. The study took place over two units: Chapter 2, *Functions and Function Relations* and Chapter 3, *Limits*. The textbook was Brief Calculus, An Applied Approach. Chapter 2 was delivered to both classes without metacognitive training. Data on content knowledge was collected before and after. Details concerning the instruments used are given below. Chapter 3 was delivered to both classes with several interludes of metacognitive training. Data similar to that collected for Chapter 2 was also collected for this chapter.

The contents of the two chapters were entirely different. The metacognitive training was supplied with material of much less familiar and more challenging nature, complicating the task of making comparisons. When we analyze the outcomes, we will take this into account.

2.2. Data Collection

This study was designed to assess the impact of a student's motivation and beliefs about mathematics and their ability to retain mathematical skills after having practiced and developed metacognitive skills. Before beginning Chapter 2, I assessed the students base knowledge by giving the students a pre-test. At the completion of Chapter 2, I gave the students the same test; see appendix A. During Chapter 2, I taught the class using my

school's standard lesson framework, teaching with Power Points, worked examples, quizzes and tests.

In the unit on Chapter 3, I gave the students a pre-test and a post-test; see appendix B. I gave the students two surveys, one before Chapter 3 and one after Chapter 3; see appendix H. The questions on the surveys were designed to gauge the students' attitudes and motivation. The surveys were completed using the online survey tool, Survey Monkey. This allowed me to know what beliefs and motivations about math the students admitted to at the beginning of the study, and this allowed me to see if any changes occurred after Chapter 3.

2.3. Metacognitive Training

Below is a calendar showing the dates on which data was collected and metacognitive training sessions were conducted.

Table 1. Training Schedule

Activity	**Day**
Survey	10/31
Learning Styles Quiz	10/31
Think Pad	11/1
Guidelines for Problem	11/2
Think Pad	11/4
Quiz Reflection	11/7
Think Pad	11/9
Think Pad	11/11
Study Guide	11/14
Test Reflection	11/15
Post-Survey	11/16

In the first metacognition training session at the beginning of the chapter 3, the students were given a learning style test; see appendix D and a multiple intelligence test; see appendix E. Some cognitive scientists have questioned the existence of learning styles and the classroom relevance of multiple intelligences, but these tests were not given in order to gather data for adjusting instruction. I gave them to the students as a metacognitive tool to help them take ownership of their learning within class. The students created a chart of the different learning styles each student had within our class, allowing us to see what were the most common and least common learning styles. The class discussed how each learning style affected how they learned math. The students discussed what types of activities helped each learning style retain the most information and which activities caused the students to easily get bored or confused. For example, one of my students identified himself as a strong kinesthetic learner and decided that the more he came to the board to work problems, the more he would remember. The activity was followed by a homework assignment that required the students to describe their learning styles and intelligences, describe what their learning styles and intelligences mean and how it affects math class, and list five strategies that will help them in math class based on their learning styles and intelligences; see appendix F.

The second metacognitive training session involved creating guidelines to encourage the students to self-assess as they worked on math. I asked the students the following questions about their math strategy. What do I do first? What do I do while I am working the problem? What do I do if I am having trouble? What do I do when I finish? Each student came to the board and filled in their answers. The students then discussed what the class had written, coming to a consensus about what steps they should

be taking each time they began to work a math problem. This was kept on a white board and left up for the entire unit for the students to reference. The purpose of this activity was to not only get the students thinking about what they know about learning math, but also to create a beginning point for developing stronger self- regulation skills; see appendix C.

Throughout the chapter, we also completed ongoing metacognitive training. In order to incorporate reflection into the student's math process, I required them to answer the questions in a 'think pad' twice a week.

Think pad:

1. What did you do well in this class?
2. What did you struggle with in this class?
3. Did you learn anything? Why or why not?
4. What would help you next time?

Figure 1. Think Pad

The goal of the think pad was to encourage the students to start training themselves to rethink their mathematical processes. Did what they tried work for them? If it did why did it work? If not how were they going to change it next time? After quizzes I would give a different think pad. Asking students to assess their studying skills, and how they would change their studying next time and why.

Reflection:

1. Did you study for this quiz? Why or Why not?
2. Was your studying effective? Why or Why not?
3. Will you change how you studying in anyway next time? Why or Why not?

Figure 2. Reflection

The final metacognitive training session was in preparation for the test. In order to guide the students on what and how to study more effectively, as a class we created a study guide. The students discussed what were the most important topics and what facts and rules they needed to know in order to solve problems based on these topics. They also discussed which examples should be included in the guide. Then one of the students wrote out on the board what the class discussed, so that each student could write it down as a learning guide for the exam. The purpose of this activity was to encourage the students to reflect on what they learned in each chapter and pull out the important facts. Many math students do not believe it is possible to study math. I wanted to show them it is possible. After the final test of Chapter 3 I asked the students to write the following one-page reflection.

Please write a one-page reflection on chapter 3
Include answers to the following:

1. Did you feel you did any better on this chapter than previous chapters?
2. Why did you do better, worse or the same?
3. Do you feel like you understand how you learn math any better?
4. Does knowing how you learn help you any in math or your other classes?
5. Doing what in class would help you learn the material better?

Figure 3. One-Page Reflection

In order to find out what the students were thinking about their thinking, I interviewed five students from each class, once before we began, once during the units, and once after the experiment was complete. I specifically asked the students how and why they answered what they answered on the tests we had in class; see appendix H. One-on-one interviews allow students to explain and think out questions posed to them, saying more than they might include in a written response in class.

CHAPTER THREE: DATA

3.1. Test Results

The pre- and post- tests were described on page fifteen and were reproduced in the appendix. The following table shows the class averages.

Table 2. Test Data

Class	Pre Test 2	Post Test 2	Pre Test 3	Post Test 3
Block 4	26%	83%	7%	93%
Block 6	24%	72.3%	4%	93%

The chief contrast between Chapter 2 and Chapter 3 is that students generally started Chapter 2 with some knowledge of the contents of the test, while they started Chapter 3 with essentially no knowledge of the contents of Chapter 3 test. They ended Chapter 2 with moderate knowledge of the tested material. They ended Chapter 3 with substantial knowledge of the tested material. Below are two charts showing each student's individual test results. In Chapter 2, there were 13 perfect scores on the post-test, while in Chapter 3; there were 20 perfect scores on the post-test.

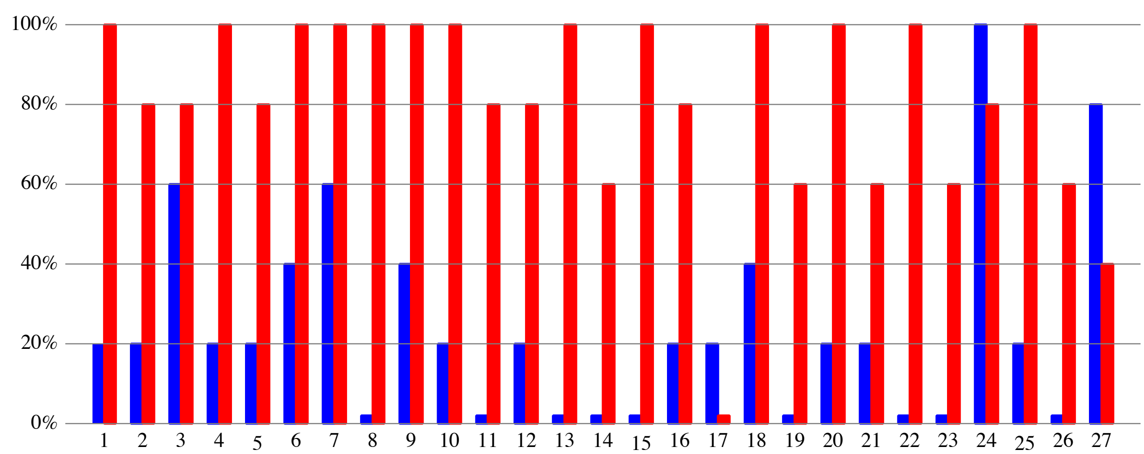


Figure 4: Chapter 2 Pre-Test (Blue) and Post-Test (Red)

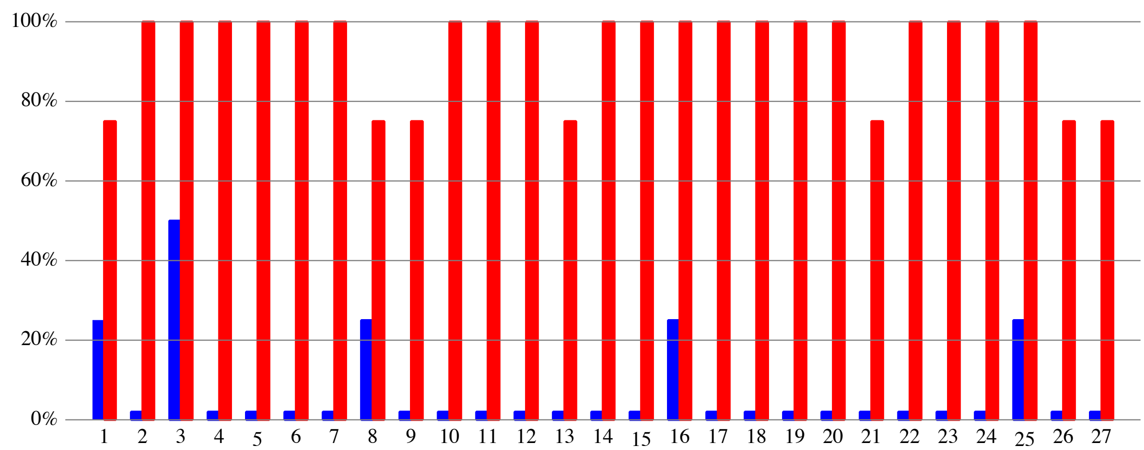


Figure 5: Chapter 3 Pre-Test (Blue) and Post-Test (Red)

3.2. Survey Results

Below is the data collected from the survey that was administered before and after Chapter 3. The data has been placed into table to show the changes that occurred.The tables show the responses from before chapter 3 and after chapter 3. Each question shows positive growth after chapter 3. This growth is confirmed by the student responses in the one page reflections discussed in the analysis. Table 3 is the student responses to the question, “Do you look forward to calculus class?” Table 4 is the response to the question, “How do you feel about math?” Table 5 is the response to the question where the students were asked to rank the following five classes: math, English, history, science, and art, using easy (E), average (A), and hard (H); see appendix H. The data in all three tables is discussed in the following chapter; see page 22.

Table 3. Responses to "I look forward to calculus class"

Selection	None	Very	Some	Often	Very
Pre	0	1	14	9	5
Post	1	2	11	14	3

Table 4. Respsonse to "How do you feel about math?"

Selection	Nightmare	Boring	Ok	Fun	Heaven
Pre	2	1	14	11	0
Post	2	1	14	13	1

Table 5. Response to "Rank your Classes"

	Math			**English**			**History**			**Science**			**Art**		
Rating	E	A	H	E	A	H	E	A	H	E	A	H	E	A	H
Pre	2	16	11	7	15	7	13	11	4	13	10	7	26	1	1
Post	6	22	3	7	15	8	15	10	6	15	12	4	27	3	0

CHAPTER FOUR: ANALYSIS

The vast majority of my students had never thought about how they learned. Teaching the students how to individualize their learning and how to reflect and adjust as they learn not only affected their content knowledge but also their attitude towards calculus class. One student said, "It showed me that I need to learn to be patient and actually try to learn all of the material given." Acquiring the belief that `I am capable of learning the material' affects a student's attitude. Before Chapter 3, 14 students looked forward to math class some of the time while 9 did often. After Chapter 3, 11 students looked forward some of the time and 14 did often. Before Chapter 3, 14 students that math was ok and 11 thought is was fun. After Chapter 3, 14 thought it was ok, 13 thought it was fun and 1 believed it to be 'heaven.' This shows a slight move towards a more positive experience in class. Before Chapter 3, 11 students ranked math as a hard class. After Chapter 3, only 4 students ranked math as a hard class. This is a significant change in attitude about math class in general. I believe that this shift in attitude was crucial to the students' knowledge gains.

There was a significant difference in the personal relationships I had with the students in my calculus classes over the students in my other classes. As Dr. Frank Neubrander states, "The students may think your class is too hard, and that you ask them to do crazy things, but if they think you care about whether or not they learn, they will be dedicated to your class" (personal communication). It was clear to me that not only were they more comfortable in class, but they had become more invested because they felt I was investing in them.

The pre and post- test data suggest that the students made more gains in content knowledge in Chapter 3 than in Chapter 2. In Chapter 2 only thirteen students received a perfect score on the post-test, while in Chapter 3 twenty students received a perfect score on the post-test. We need to be cautious drawing conclusions, however, since we are comparing progress on different material and using different tests. One possible explanation would be that the material on the Chapter 2 test was harder to master, but the student's began with some exposure, while the material on the Chapter 3 test was easier but initially less familiar. However, in previous years teaching calculus, Chapter 3 has been more difficult than Chapter 2, and once I even needed to repeat that chapter. In the year following this study I had my students take the same test for their Chapter 3 without any metacognitive training and they averaged a 67% on the test. Having two other classes who did not receive treatment do significantly poorer on the content strengthens the idea that metacognitive training did have a positive impact on my students.

Upon asking the students why they felt they had done better on the third chapter, they all responded with very similar answers. The students overwhelming felt that "if they knew how they learned, they could better know how to study."

They performed better in not only math class, but in other classes as well. What surprised me was how much metacognition the students took to their other classes. One students said, "Figuring out what kind of learner I am has helped me not only in math class, but every class I feel. It seems that I have been using the tips given to us by the surveys even when doing homework. I even wish other teachers would do this so they would know what kind of learners we are and could try to accommodate our needs." Students applied the thinking I had them doing about their math work to thinking about

how they were doing work in each of their classes, and even applied it to how each teacher presented material in class. Knowing how a student needs to adjust what they do in each class depending on how the material is presented is a skill we worked on throughout the unit. Another student said, “Knowing what my learning style is, I can adjust the way I behave in class depending on how the teacher is presenting the material. If they aren’t using my learning style, I know I need to pay extra attention, take very thorough notes, and participate in any way I can.”

The LSU Center for Academic Success also provides metacognitive interventions for students struggling in their courses. They give students activities and lessons similar to those I provided to my students. The results they achieve at LSU are similar in terms of increased learning success and changes in attitude. This supports the belief that various student populations, of varying ages and socioeconomic backgrounds, may be aided by metacognitive interventions.

CHAPTER FIVE: CONCLUSION

While some students naturally develop metacognitive skills over time, most students do not. Teaching students to reflect and analyze how they think and learn allows students to not only develop a deeper understanding of the content, but also gives the students a deeper sense of personal achievement. A student is more likely to invest in the content if they feel they can learn the material.

Even though the results showed a positive correlation between learning metacognitive skills and retaining content, there were still limitations and restrictions. The major limitation is that chapter 3 had different content than chapter 2. We were not able to arrange a classical controlled study. However, based on the literature, other MNS thesis, and LSU's research, we have strong indications that metacognitive training is beneficial to student learning as well as student attitudes. I suggest that further research should be done in the high school setting with a large number of students and various teachers all doing a set of activities designed to encourage metacognition within mathematics.

REFERENCES

Armstrong, T. 2013. Implementing and Managing Self-Assessment Procedures, May 2013, Masters of Natural Science Thesis, Louisiana State University.

Boekarts, Seegers, Vermeer. 1995. Solving Math Problems: Where and Why Does the Solution Process Go Astray? Educational Studies in Mathematics 28: 241-262.

Coutinho, A. Newman,G. 2008. A model of metacognition, achievement goal orientation, learning style and self-efficacy. Learning Environment Res. 11:131-151.

Flavell, J. 1976. Metacognitive aspects of problem solving. In L.B. Resnick (Ed.), The nature of intelligence (pp.231-236) Hillsdale, NJ: Erlbaum.

Fox, E. Riconsente, M. 2008. Metacognition and Self Regulation in James, Piaget, and Vygotsky. Educational Psychology Review. 20:373-389.

Gama, C. Metacognition in Interactive Learning Environments: The reflection Assistant Model. 668-677.

Garogalo, J. Lester, F. 1985. Metacognition, Cognitive Monitorings, and Mathematical Performance. Journal for Research in Mathematics Education.16: 163-176.

Hennessey, G. 1999. Probing the Dimensions of Metacognition: Implications for Conceptual Change Teaching-Learning. Presented at Annual Meeting of National Association for Research in Science Teaching.

Hotard, D. 2009. The Effect of Self- Assessment on Student Learning of Mathematics. August 2010. Masters of Natural Sciences Thesis, Louisiana State University.

Lester Jr., F. 1994 Mathematical Problem Solving Research: Journal for Research in Mathematics Education 25: 660-675.

Miller,T. Geraci, L. 2011. Training metacognition in the classroom: the influence of incentives and feedback on exam predictions. Metacognition Learning. December 2011 Volume 6. Issue 3, pp 303-314.

Pintrich, P. 2002. The Role of Metacognitive Knowledge in Learning, Teaching, and Assessing. Theory in Practice 41: 219-225.

Reif, F. 2008 Applying Cognitive Science to Education. Massachusetts Institute of Technology Press, Cambridge, Massachusetts.

Shoenfeld, A.H. 1983. Beyond the Purely Cognitive: Metacognition and Social Cognition as Driving Forces in Intellectual Performance. Paper presented at the Annual Meeting of

the American Educational Research Association (66th, New York, NY, March 19-23, 1982).

Shoenfeld, A.H. 1992. Learning to Think Mathematically: Problem Solving, Metacognition, and Sense-Making in Mathematics. In D. Grouws (Ed.), Handbook for Research on Mathematics Teaching and Learning (pp. 334-370). New York. MacMillan.

Sullivan, M. 2005. Brief Calculus: an applied approach. John Wiley &Sons, Inc. Hoboken, NJ.

Underwood, J. 2012. Do Learning Logs Have an Impact on the Conceptual Mastery of Force and Motion. August 2012, Masters of Natural Sciences Thesis, Louisiana State University.

Vrugt, A & Oort, F. 2008 Metacognition achievement goals, study strategies and academic achievement: Pathways to achievement. Metacognition Learning 30:123-146.

Wilson, N. & Bai, H. 2010. The relationships and impact of teachers' metacognitive knowledge and pedagogical understandings of metacognition. Metacognition and Learning 5, pp 269-288.

APPENDIX A: PRE/POST TEST CHAPTER 2

Name: **Block:**

Find the end behavior of the function.

$f(x) = 5x^6 - 7x^4 + 8x - 10$

Convert each exponential expression to an equivalent expression involving a logarithm.

$5^2 = z$

Convert each logarithmic expression to an equivalent expression involving an exponent.

$log_5 u = 13$

Find the domain of each logarithmic function.

$f(x) = \log_5(2x+1)$

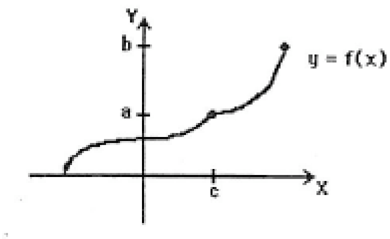
Evaluate each expression.

$log_3(\frac{1}{3})$

APPENDIX B: PRE/POST TEST CHAPTER 3

Name:

Use the graph to determine whether Error! Objects cannot be created from editing field codes. **exists. If the limit does not exist, explain.**



Find the indicated limit and show all work. Show all properties where necessary.

$\boldsymbol{lim_{x \to 1}(3x^2 - x + 4)}$

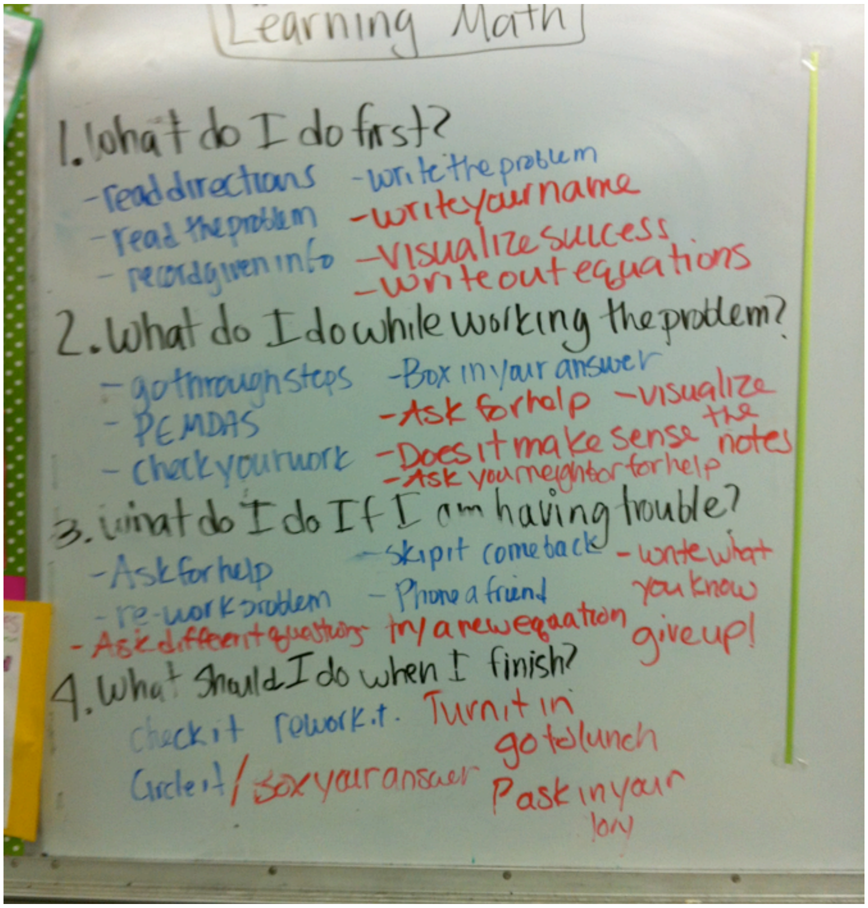
$\lim_{x \to 1} \sqrt{4x^2 + 4x + 1}$

Evaluate the limits at infinity and the infinite limits.

$\boldsymbol{lim_{x \to \infty} \frac{x^3 - 2x^2 + 3x - 1}{2x^3 - x^2 + x - 5}}$

Find the average rate of change of $f(x) = 2x^2 - x$ **from** $\boldsymbol{c}$ **to** $\boldsymbol{x}$ **if c=2.**

APPENDIX C: GUIDELINES FOR CLASSWORK



APPENDIX D: LEARNING STYLE TEST

For these questions, choose the first answer that comes to mind and click on a,b, or c. Don't spend too much time thinking about any one question.

Question 1

When you study for a test, would you rather

- a) read notes, read headings in a book, and look at diagrams and illustrations.
- b) have someone ask you questions, or repeat facts silently to yourself.
- c) write things out on index cards and make models or diagrams.

Question 2

Which of these do you do when you listen to music?

- a) daydream (see things that go with the music)
- b) hum along
- c) move with the music, tap your foot, etc.

Question 3

When you work at solving a problem do you

- a) make a list, organize the steps, and check them off as they are done
- b) make a few phone calls and talk to friends or experts
- c) make a model of the problem or walk through all the steps in your mind

Question 4

When you read for fun, do you prefer

- a) a travel book with a lot of pictures in it
- b) a mystery book with a lot of conversation in it
- c) a book where you answer questions and solve problems

Question 5

To learn how a computer works, would you rather

- a) watch a movie about it
- b) listen to someone explain it
- c) take the computer apart and try to figure it out for yourself

Question 6

You have just entered a science museum, what will you do first?

- a) look around and find a map showing the locations of the various exhibits
- b) talk to a museum guide and ask about exhibits

c) go into the first exhibit that looks interesting, and read directions later

Question 7

What kind of restaurant would you rather not go to?

- a) one with the lights too bright
- b) one with the music too loud
- c) one with uncomfortable chairs

Question 8

Would you rather go to

- a) an art class
- b) a music class
- c) an exercise class

Question 9

Which are you most likely to do when you are happy?

- a) grin
- b) shout with joy
- c) jump for joy

Question 10

If you were at a party, what would you be most likely to remember the next day?

- a) the faces of the people there, but not the names
- b) the names but not the faces
- c) the things you did and said while you were there

Question 11

When you see the word "d - o - g", what do you do first?

- a) think of a picture of a particular dog
- b) say the word "dog" to yourself silently
- c) sense the feeling of being with a dog (petting it, running with it, etc.)

Question 12

When you tell a story, would you rather

- a) write it
- b) tell it out loud
- c) act it out

Question 13

What is most distracting for you when you are trying to concentrate?

- a) visual distractions
- b) noises
- c) other sensations like, hunger, tight shoes, or worry

Question 14

What are you most likely to do when you are angry?

- a) scowl
- b) shout or "blow up"
- c) stomp off and slam doors

Question 15

When you aren't sure how to spell a word, which of these are you most likely to do?

- a) write it out to see if it looks right
- b) sound it out
- c) write it out to see if it feels right

Question 16

Which are you most likely to do when standing in a long line at the movies?

- a) look at posters advertising other movies
- b) talk to the person next to you
- c) tap your foot or move around in some other way

If you scored mostly a's you may have a visual learning style. You learn by seeing and looking.

Visual Learners

- take numerous detailed notes
- tend to sit in the front
- are usually neat and clean
- often close their eyes to visualize or remember something
- find something to watch if they are bored
- like to see what they are learning
- benefit from illustrations and presentations that use color

- are attracted to written or spoken language rich in imagery
- prefer stimuli to be isolated from auditory and kinesthetic distraction
- find passive surroundings ideal

If you scored mostly b's, you may have an auditory learning style. You learn by hearing and listening.

Auditory Learners

- sit where they can hear but needn't pay attention to what is happening in front
- may not coordinate colors or clothes, but can explain why they are wearing what they are wearing and why
- hum or talk to themselves or others when bored
- acquire knowledge by reading aloud
- remember by verbalizing lessons to themselves (if they don't they have difficulty reading maps or diagrams or handling conceptual assignments like mathematics).

If you had mostly c's, you may have a kinesthetic learning style. You learn by touching and doing.

Kinesthetic Learners

- need to be active and take frequent breaks
- speak with their hands and with gestures
- remember what was done, but have difficulty recalling what was said or seen
- find reasons to tinker or move when bored
- rely on what they can directly experience or perform
- activities such as cooking, construction, engineering and art help them perceive and learn
- enjoy field trips and tasks that involve manipulating materials
- sit near the door or someplace else where they can easily get up and move around
- are uncomfortable in classrooms where they lack opportunities for hands-on experience
- communicate by touching and appreciate physically expressed encouragement, such as a pat on the back

APPENDIX E: LEARNING STYLE TEST 2

Part I

Complete each section by placing a “1” next to each statement you feel accurately describes you. If you do not identify with a statement, leave the space provided blank. Then total the column in each section.

Section 1

_____ I enjoy categorizing things by common traits
_____ Ecological issues are important to me
_____ Classification helps me make sense of new data
_____ I enjoy working in a garden
_____ I believe preserving our National Parks is important
_____ Putting things in hierarchies makes sense to me
_____ Animals are important in my life
_____ My home has a recycling system in place
_____ I enjoy studying biology, botany and/or zoology
_____ I pick up on subtle differences in meaning

_____ TOTAL for Section 1

Section 2

_____ I easily pick up on patterns
_____ I focus in on noise and sounds
_____ Moving to a beat is easy for me
_____ I enjoy making music
_____ I respond to the cadence of poetry
_____ I remember things by putting them in a rhyme
_____ Concentration is difficult for me if there is background noise
_____ Listening to sounds in nature can be very relaxing
_____ Musicals are more engagingto me than dramatic plays
_____ Remembering song lyrics is easy for me

_____ TOTAL for Section 2

Section 3

_____ I am known for being neat and orderly
_____ Step-by-step directions are a big help
_____ Problem solving comes easily to me
_____ I get easily frustrated with disorganized people
_____ I can complete calculations quickly in my head
_____ Logic puzzles are fun
_____ I can't begin an assignment until I have all my "ducks in a row"
_____ Structure is a good thing
_____ I enjoy troubleshooting something that isn't working properly
_____ Things have to make sense to me or I am dissatisfied

_____ TOTAL for Section 3

Section 4

_____ It is important to see my role in the “big picture” of things
_____ I enjoy discussing questions about life
_____ Religion is important to me
_____ I enjoy viewing art work
_____ Relaxation and meditation exercises are rewarding to me
_____ I like traveling to visit inspiring places
_____ I enjoy reading philosophers
_____ Learning new things is easier when I see their real world application
_____ I wonder if there are other forms of intelligent life in the universe
_____ It is important for me to feel connected to people, ideas and beliefs

_____ TOTAL for Section 4

Section 5

_____ I learn best interacting with others
_____ I enjoy informal chat and serious discussion
_____ The more the merrier
_____ I often serve as a leader among peers and colleagues
_____ I value relationships more than ideas or accomplishments
_____ Study groups are very productive for me
_____ I am a “team player”
_____ Friends are important to me
_____ I belong to more than three clubs or organizations
_____ I dislike working alone

_____ TOTAL for Section 5

Section 6

_____ I learn by doing
_____ I enjoy making things with my hands
_____ Sports are a part of my life
_____ I use gestures and non-verbal cues when I communicate
_____ Demonstrating is better than explaining
_____ I love to dance
_____ I like working with tools
_____ Inactivity can make me more tired than being very busy
_____ Hands-on activities are fun
_____ I live an active lifestyle

_____ TOTAL for Section 6

Section 7

_____ Foreign languages interest me
_____ I enjoy reading books, magazines and web sites

_____ I keep a journal
_____ Word puzzles like crosswords or jumbles are enjoyable
_____ Taking notes helps me remember and understand
_____ I faithfully contact friends through letters and/or e-mail
_____ It is easy for me to explain my ideas to others
_____ I write for pleasure
_____ Puns, anagrams and spoonerisms are fun
_____ I enjoy public speaking and participating in debates

_____ TOTAL for Section 7

Section 8

_____ My attitude effects how I learn
_____ I like to be involved in causes that help others
_____ I am keenly aware of my moral beliefs
_____ I learn best when I have an emotional attachment to the subject
_____ Fairness is important to me
_____ Social justice issues interest me
_____ Working alone can be just as productive as working in a group
_____ I need to know why I should do something before I agree to do it
_____ When I believe in something I give more effort towards it
_____ I am willing to protest or sign a petition to right a wrong

_____ TOTAL for Section 8

Section 9

_____ Rearranging a room and redecorating are fun for me
_____ I enjoy creating my own works of art
_____ I remember better using graphic organizers
_____ I enjoy all kinds of entertainment media
_____ Charts, graphs and tables help me interpret data
_____ A music video can make me more interested in a song
_____ I can recall things as mental pictures
_____ I am good at reading maps and blueprints
_____ Three dimensional puzzles are fun
_____ I can visualize ideas in my mind

_____ TOTAL for Section 9

Part II

Now carry forward your total from each section and multiply by 10 below:

Section	Total Forward	Multiply	Score
1		X10	
2		X10	
3		X10	
4		X10	
5		X10	
6		X10	
7		X10	
8		X10	
9		X10	

Linguistic intelligence involves sensitivity to spoken and written language, the ability to learn languages, and the capacity to use language to accomplish certain goals. This intelligence includes the ability to effectively use language to express oneself rhetorically or poetically; and language as a means to remember information. Writers, poets, lawyers and speakers are among those that Howard Gardner sees as having high linguistic intelligence.
Logical-mathematical intelligence consists of the capacity to analyze problems logically, carry out mathematical operations, and investigate issues scientifically. In Howard Gardner's words, it entails the ability to detect patterns, reason deductively and think logically. This intelligence is most often associated with scientific and mathematical thinking.
Musical intelligence involves skill in the **performancLe**, composition, and appreciation of musical patterns. It encompasses the capacity to recognize and compose musical pitches, tones, and rhythms. According to Howard Gardner musical intelligence runs in an almost structural parallel to linguistic intelligence.
Bodily-kinesthetic intelligence entails the potential of using one's whole body or parts of the body to solve problems. It is the ability to use mental abilities to coordinate bodily movements. Howard Gardner sees mental and physical activity as related.
Spatial intelligence involves the potential to recognize and use the patterns of wide space and more confined areas.
Interpersonal intelligence is concerned with the capacity to understand the intentions, motivations and desires of other people. It allows people to work effectively with others. Educators, salespeople, religious and political leaders and counsellors all need a well-developed interpersonal intelligence.
Intrapersonal intelligence entails the capacity to understand oneself, to appreciate one's feelings, fears and motivations. In Howard Gardner's view it involves having an effective working model of ourselves, and to be able to use such information to regulate our lives.

How You Think!

For this assignment I want you to creatively describe how you learn.

1. Include your learning style (s) and intelligences
2. Describe what you learning style means and how it affects math class
3. Five strategies that help you based on your learning style and intelligences with math
4. Be colorful

20 pts = 5 pts for each part

APPENDIX G: STUDENT LEARNING STYLE ASSIGNMENT

APPENDIX H: SURVEY QUESTIONS

Pre- Chapter 3 survey

1. What is your name?
2. I look forward to coming to calculus class:
   None, very little, some, often, very often
3. Why do you look forward to calculus or why don't you?
4. How do you feel about math?
   Nightmare, boring, ok, fun, heaven
5. What is your favorite part of math class, what is your least favorite?

Post-Chapter 3 Survey

1. What is your name?
2. What helps you learn math? Why?
3. What has stopped you from learning math? Why?
4. What goals do you have for calculus class?
5. How do you study for math? Why?
6. Rank the following classes from easy, average to hard:
   Math, English, Science, History, Art

APPENDIX I: INTERVIEW QUESTIONS

Interview 1

1. What were your first thoughts when you looked at the pretest?
2. What strategies did you use to solve the problems? Why?
3. What strategies did you use when you did not know what to do? Why?

Interview 2

1. How did you feel about the post test?
2. What strategies did you use to solve this time? Where they different?
3. What did you do to study for the test? Why? Did it work?
4. How do you learn math? Why?
5. What is the easiest part of math? The hardest?

Interview 3

1. What did you do to study for this test? Why?
2. What strategies are you using in math? Have they changed?
3. How do you learn math? Why?
4. What is the easiest part of math? The hardest?
5. How did you feel about this test? Was it different than the last test? Why?

APPENDIX J: IRB

Application for Exemption from Institutional Oversight

LSU
Institutional Review Board
Dr. Robert Mathews, Chair
131 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.6792
irb@lsu.edu
lsu.edu/irb

Unless qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/ projects using living humans as subjects, or samples, or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

-- Applicant,Please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the IRB. Once the application is completed, please submit two copies of the completed application to the IRB Office or to a member of the Human Subjects Screening Committee. Members of this committee can be found at http://www.lsu.edu/screeningmembers.shtml

-- A Complete Application Includes All of the Following:
(A) Two copies of this completed form and two copies of part B thru E.
(B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1&2)
(C) Copies of all instruments to be used.
*If this proposal is part of a grant proposal, include a copy of the proposal and all recruitment material.
(D) The consent form that you will use in the study (see part 3 for more information.)
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing or handling data, unless already on file with the IRB. Training link: (http://phrp.nihtaining.com/users/login.php.)
(F) IRB Security of Data Agreement: (http://www.lsu.edu/irb/IRB%20Security%20of%20Data.pdf)

1) Principal Investigator: Bonnie Bergstresser **Rank:** Student

Dept: MNS **Ph:** (225)276 7689 **E-mail:** Bonniesuetb@hotmail.com

2) Co Investigator(s): please include department, rank, phone and e-mail for each

James Madden, Math, Professor, 978-3525
madden@math.lsu.edu

IRB# E5565 LSU Proposal #
Complete Application
Human Subjects Training

3) Project Title: Inquiry in Calculus

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 7-17-2014

4) Proposal? (yes or no) no **If Yes, LSU Proposal Number**

Also, if YES, either
○ **This application completely matches the scope of work in the grant**
OR
○ **More IRB Applications will be filed later**

5) Subject pool (e.g. Psychology students)

*Circle any **"vulnerable populations" to be used:** (children <18; the mentally impaired, pregnant women, the ages, other). Projects with incarcerated persons cannot be exempted.

6) PI Signature [signature] **Date** 6/30/11 (no per signatures)

**** I certify my responses are accurate and complete.** If the project scope or design is later changes, I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at LSU for three years after completion of the study. If I leave LSU before that time the consent forms should be preserved in the Departmental Office.

Screening Committee Action: Exempted √ Not Exempted ___ Category/Paragraph 1

Reviewer Mathews **Signature** [signature] **Date** 7/18/11

Parental Permission Form

Project Title: Inquiry in Calculus

Performance Site: Episcopal High School

Investigators: The following investigator is available for questions,

M-F, 7:30am – 3:30 pm

Bonnie Bergstresser

Mathematics Dept.

bonniesueb@hotmail.com

Purpose of the study: The Purpose of this research project is to develop effective strategies for teachers to use in teaching limits in Calculus

Inclusion Criteria: Students in regular calculus

Description of the study: Over a period of the school year, the investigator, will scaffold problems solving techniques through collaborative group work, individual reflection, and whole class discussion. The students will be writing bi weekly journal entries discussing their understanding of the content covered in class. This information will be used to adjust lessons to improve student understanding.

Benefits: Research shows that if students develop the ability to discuss, question, and problem solve; they will develop a deeper understanding of the mathematics

Risks: There are no known risks

Right to Refuse: Participation is voluntary, and a child will become part of the study only if both child and parent agree to the child's participation At any time, either the subject may withdraw from the study or the subject's parent may withdraw the subject from the study without penalty or loss of any benefit to which they might otherwise be entitled. Students participating will not be asked to do anything outside of normal class procedures, their work will simply not be included in the data recorded.

Privacy: The school records of participants in this study may be reviewed by Investigators. Results of the study may be published, but no names or identifying information will be included for publication. Subject identity will remain confidential unless disclosure is required by law.

Financial Information: There is no cost for participation in the study, nor is there any compensation to the subjects for participation.

Signatures:

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigator. If I have questions about subjects' rights or other concerns, I can contact Robert C. Mathews, Chairman, Institutional Review Board, (225) 578-8692, irb@lsu.edu, www.lsu.edu/irb. I will allow my child to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

Parent's Signature:________________________

Date:______________

The parent/guardian has indicated to me that he/she is unable to read. I certify that I have read this consent from to the parent/guardian and explained that by completing the signature line above he/she has given permission for the child to participate in the study.

Signature of Reader:________________________

Date:______________

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 | www.lsu.edu/irb
Exemption Expires: 7-17-2014

Child Assent Form

I,______________________________, agree to be in a study to find ways to help students learn calculus. I understand I will not be asked to do anything more than what we are already doing in class. I can decide to stop being in the study at any time without being penalized.

Child's Signature:___________________________ Age:_____
Date:________________

Witness* _________________________________ Date:________________

* (N.B. Witness must be present for the assent process, not just the signature by the minor.)

Study Exempted By:
Dr. Robert C. Mathews, Chairman
Institutional Review Board
Louisiana State University
203 B-1 David Boyd Hall
225-578-8692 I www.lsu.edu/irb
Exemption Expires: 7-17-2014

VITA

Bonnie Bergstresser received her bachelor's degree at the Georgia Institute of Technology in 2005. Thereafter, she taught school in Baton Rouge, Louisiana. As her interest in teaching grew, she made the decision to enter graduate school in the LAMSTI program at Louisiana State University. She will receive her master's degree in August 2013 and plans to begin work on her doctorate as well as continue teaching upon graduation.