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JOURNALING IN A SECONDARY MATHEMATICS CLASSROOM

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Submitted in partial fulfillment
of the requirements for the degree of
Master of Education
Moravian College
Bethlehem, Pennsylvania
2003

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ACKNOWLEDGEMENTS

First and foremost, I must thank my husband, Angel, for putting up with countless nights of frozen pizza, dirty dishes, computer hogging, temporary insanity, and endless other inconveniences. Thanks for helping me stay focused on “what’s really important” and making my journey through this process easier.

I would also like to thank my students for being such willing “guinea pigs” and for constantly challenging me to become a better teacher.

And last, but certainly not least, I would like to thank Dr. Joseph Shosh and my fellow thesis survivors for encouraging, supporting and inspiring me to new heights!

TABLE OF CONTENTS

| | |
|---|-----|
| ACKNOWLEDGEMENTS | iii |
| HOW IT ALL STARTED | 1 |
| MY QUESTION | 5 |
| REVIEW OF THE LITERATURE | 5 |
| RESEARCH DESIGN | 21 |
| Collection of Data | 26 |
| Trustworthiness | 28 |
| MY RESEARCH STUDY | 30 |
| My Class | 30 |
| Initial Feelings Toward Journaling | 32 |
| Journal Activities | 35 |
| The Learning Log: Journal #5 | 35 |
| The Open-Ended Journal: Journal #6 | 40 |
| The Collaborative/Spontaneous Journal: Journal #7 | 45 |
| The Review Learning Log: Journal #8 | 48 |
| My Students | 53 |
| Meridith vs. Jessica | 54 |
| Brandon | 57 |
| Michael and the Helicopter Problem | 59 |
| Mary's Change of Heart | 62 |
| MY FINDINGS | 66 |
| Methods of Analysis | 66 |
| Findings | 67 |
| NEW QUESTIONS | 80 |
| BIBLIOGRAPHY | 84 |
| APPENDICES | |
| A Survey 1 | 86 |
| B Survey 2 | 87 |
| C Principal Permission Letter | 88 |
| D Parental Consent Letter | 89 |

HOW IT ALL STARTED

I have always believed that learning and teaching are symbiotic processes that happen best when teacher and student work one-on-one. I remember as a high school student being able to pinpoint the exact moment another student started misunderstanding the teacher. I remember being able to rephrase what the teacher said, so that my fellow student would understand it. Even within a classroom of twenty to thirty students, this process is one-on-one. Each student hears the teacher's words from a different perspective. Each student takes a slightly different meaning from the process that goes on in a classroom each day. Each student learns in his or her own unique way.

Similarly my teaching style responds in one way or another to individuals in my classroom. Unfortunately, with today's class size and time frame, it is impossible for me to be aware of each of my students' individual needs all of the time. I can only take in so much sensory data while teaching. Only certain students feel comfortable asking questions in class. Still fewer students come to see me before or after school for extra help. Furthermore, class size makes it impossible to meet with each of my students individually on a regular basis. So I have found that I must search for better ways of communicating individually with my students.

Here enters the idea of journaling. I was first intrigued by the idea of journaling in my math classroom last spring. I had heard about it and read about

since I was an undergrad at Penn State, but I had never tried it with my own students. As I was searching for thesis topics, I pondered the idea of doing journaling. My husband and I were discussing my thoughts about journaling when he told me that the only math class that he ever felt made a significant impact on his life was his 4th grade class, which used math journals. This impressed me. I decided to do a mini-pilot study in my Algebra I class that semester. We used journals for about five weeks at the beginning of the semester. I found that class to be the most enjoyable math class of my teaching career. Although we did not continue journaling the entire semester, the initial use of the journals somehow seemed to encourage a bond that created a family-like class environment. My students also produced rich responses to the journal activities, which helped me to gain insight into how they were thinking about the problem. I was able to encourage students who found it frustrating to try to communicate their mathematical thinking. In a practical sense, journaling helped me to take my students to a higher thinking level than they had been used to.

From this mini-pilot study I developed some questions about journaling and some hopes about what a more systematic use of journals might accomplish in a math classroom. Going into this thesis research I had hopes that journaling would provide an additional opportunity to communicate one-on-one with my students. While the journal would not provide face-to-face communication, it would hopefully promote an ongoing dialogue. Students would respond to a

prompt, and I, in turn, would respond to their unique journal with an equally unique reply. I also hoped that journaling would be an opportunity for students to freely write their thoughts about math without fear of any repercussion. I believed journals should be used as a safe place to ask questions and seek help. Students, who are too shy to come to me personally or ask in front of their peers, would have a place that they could raise their question. If nothing else, journaling might provide another means of communication between teachers and students. I also believed that journaling might be the key to deepen students' understanding and mathematical communication skills. On a personal level, through this study I was hoping to find a way to improve my teaching practice.

I recognize that in conducting this study I had several potential biases. One bias came from my position as teacher. Of course, I wanted this study to "succeed." This put me in a more optimistic opinion immediately. I was looking to see the good side to everything. No teacher likes to think about ideas that have been flops. Quite often these memories are painful. To avoid looking at my data with rose-colored glasses I continually looked, along with the members of my researcher support group, for potential negative cases, and I employed a variety of data collection techniques to gain multiple perspectives on my study.

Another potential bias that I needed to confront was my own enjoyment of writing. If I can learn through writing, why can't my students? Some of my students might have genuinely disliked writing and might have had a difficult

time with the journals. I might not have liked to consider the possibility of journals not working for a student, simply because they worked for me.

My final potential bias, although I'm sure that there were more, was that I had been indoctrinated in a traditional educational environment. I was taught mathematics in a traditional way. I had never experienced a non-traditional math class, outside of one or two college courses. This put me in a more pessimistic stance. If my teachers didn't use this then why should I go to all the trouble? I have all this content to cover, so how could I possibly make time for journaling activities? These were real concerns that plagued me in spite of my desire for journaling to "work." I was concerned that this bias might do the most damage to my study.

Throughout my study I sought to overcome these biases. I recognized going into the study that journaling would not work for every student. I recognized that in order to make an honest attempt at using journals in my classroom I needed to "let go" a little more. I also realized that I could not be so enthusiastic about making journals "work" that I would forget to make sure that my students were learning. My first and foremost goal in this study was to be the best teacher that I could be even if that meant putting my research agenda on the backburner.

MY QUESTION

I developed several questions about journaling in a math classroom from my mini-pilot study as well as from reading research. These questions developed as my study progressed, but the core ideas remained the same. My “big” question was, “What impact does math journaling have on students’ experience in a math classroom?”

My more refined goals included the following:

1. To investigate the impact of journaling on student motivation in a Trigonometry/Pre-Calculus classroom.
2. To assess the effectiveness of journaling at alleviating students’ math anxiety.
3. To document the reported and observed experiences of students and teacher in a Trigonometry/Pre-Calculus classroom when journals are a regular part of classroom activities.
4. To explore the use of journals as a communication tool between students and teacher in a Trigonometry/Pre-Calculus classroom.
5. To examine students’ critical thinking and metacognition through journal writing in a Trigonometry/Pre-Calculus classroom.

REVIEW OF THE LITERATURE

In my pursuit to learn all that I could about journaling I read a variety of sources including both formal and informal research studies. In this section I will attempt to summarize the research that most impacted my study.

Aspinwall and Miller (1997) designed their study to “examine the effects of written expression about mathematical ideas on conceptual understanding” (p. 253). The study took place in a first-semester calculus class at a university in

Southeastern U.S. Action-research methods were applied when collecting data. Three main changes were made to the course. Cooperative group learning was implemented. Students were required to complete writing tasks with the intention that these tasks would hold students accountable and give them a chance to practice their communication skills. Finally, alternative assessment was used in the form of new test items requiring explanation. The researchers kept journals on their observations, and the students kept journals in which they responded to writing prompts. Taped interviews were also completed. I opted to incorporate several of these ideas. I included cooperative group work for many of our journals, and students were required to complete journals, although they were not graded. I also included several new test items that reflected our journal activities; however, this was not the main focus of my research. Aspinwall and Miller make several conclusions as a result of this study. First, for most students writing in a math classroom was a new idea. Students initially found that the task was difficult. As the semester continued, the researchers found that many students began to rely on writing for conceptual understanding. As this increased, students' attitudes toward the writing improved. Finally, students learned more than just the concepts of calculus as a result of the writing activity. I anticipated that journaling would also be a new idea for most of my math students, and I expected that I might encounter some resistance. The researchers mentioned that several of their students returned to them and told them that learning to write

mathematically had revolutionized the way that they would approach mathematics in the future. If nothing else, this was extremely encouraging to me. The article also provided example prompts and portions of a sample interview protocol. These prompts helped me when I was creating my own prompts for my trig/pre-calc classroom.

Carr's (2002) article described assessment techniques, which the author hoped, would provide teachers with "tools to understand the mental processes students engage in as they read, write and problem solve" (p. 156). The author also hoped that these tools would encourage students to become "more active participants in their education" (p. 156). The author discussed journals and learning logs as a technique designed to show how students learn and to support student self-reflection. The author believed that journals would offer invaluable information on understanding, misconceptions, biases, questions, and difficulties students may have. Journals differ from learning logs, according to Carr in that they should follow a more narrative format and allow for feelings, opinions and personal experiences, making them more subjective. Learning logs, on the other hand, are intended to be more objective where students respond to what they are learning. Carr offered questions from teachers trying to implement journals or learning logs. I found this article gave me practical ideas on what I could include in my journal activities. In my study, I did not differentiate between "learning logs" and "journals" for my students. These are categories which I use for the

purpose of clarification in this thesis, but which I did not specify in my classroom. However, I designed my prompts with these ideas in mind. I created prompts which allowed for objective response to content related topics and prompts which allowed for more of the subjective response that Carr mentions, including misconceptions, biases, questions, etc.

Gordon and Macinnis (1993) present a specific form of writing activity, which they called dialogue journals. They defined dialogue journals as, “a written conversation, or a talk on paper, between a student and a teacher” (p. 37). This dialogue provided all students a non-threatening opportunity to communicate with their teacher about a variety of issues and concerns. The authors encouraged the use of two types of dialogue journals, prompted writing and open-ended writing. Gordon and Macinnis used journals for one year for 180 students in 4th, 5th and 6th grade math classes at a Canadian magnet school with an overall philosophy of integrating subjects across the curriculum. Students were given 10-15 minutes each day to complete their journals. The authors found that no motivational techniques seemed to be necessary and that often journal entries were spontaneous. In other words, students could initiate the journal writing activity. From this study the authors were able to determine students’ conceptual knowledge on the decimal system and their misconceptions. They also found that students were aware of the strengths and weaknesses that affected their learning and what worked or did not work for them as learners. They also found that

students were willing to share their difficulties on topics because the journals were not used as an evaluation. Overall the authors found that the journals provided a window on the students' thinking processes. While this research study was conducted informally, it evidenced some powerful ideas. It confirmed an observation I made during my pilot study, suggesting I would not have to use motivational techniques to get students to write in their journals. I did periodically have discussions with my class on how journals might help them, to motivate the skeptical students. I felt that offering motivation, such as counting the journal as a grade, would hinder the openness of students' responses. The authors of this study seemed to confirm that idea as well. My students were extremely grade-conscious, and I felt that grading the journals would add to their grade anxiety. The idea to give ten to fifteen minutes each day to work on journal activities also came from this study, as did the concept of initiating dialogue between teacher and students. Although I did not specifically use the term dialogue journals in my class, I encouraged my students to feel free to ask questions of me in their response, and I responded to every journal in some fashion.

Johanning (2000) attempted to understand, "how middle school students think about and approach problems while they wrote descriptions of why and how they solve problems" (p. 100). The study took place in a 7th and 8th grade pre-algebra program in a junior high school of approximately 320 students. A total of

48 students participated in the year-long study. Participants in the study were either considered gifted (7th graders) or advanced (8th graders). Students responded to seventeen problem-writing prompts throughout the year. They were required to write detailed descriptions of their approach to non-routine problems, and then they discussed and evaluated these approaches in groups. The researcher analyzed these writings using qualitative methods, including participation in group discussions, audio-taping of the discussions, and interviews of the students. The researcher found that students used a variety of strategies to solve the problems, and it was possible to find a rationale for what they did and why they did it in their explanations. Students indicated that writing helped them to find their mistakes, to remember the problem and to understand the problem more. Overall, the understanding that was developed by the writing activity was enhanced by the group activity afterwards. In turn, the students' thinking enhanced the teacher's instruction. This study brought the idea of writing and group work together in a secondary setting. I found the idea of discussing the writing in group-work to be fascinating. Although I did not specifically have my students respond to each other's writing, they did work together in groups.

Lesnak's (1989) purpose was to measure the benefits of using writing-to-learn in the teaching of basic algebra. This study involved four basic algebra classes consisting of 26 students in each class. Two classes acted as the control group. The author used the same methods and techniques he had been using for

25 years in that group. The other two classes participated in the revised syllabus including writing-to-learn activities. Using statistical analysis of overall grades, the author found that the group using the writing-to-learn activities had an average grade that was 3.2% higher than the control group with a level of significance at 4.6%, suggesting that this did not happen by chance. Qualitatively the author found that all participants of his writing group found the experience to be positive, including students who did not pass the course. Students indicated in a final writing activity that they found that the writing-to-learn method helped reduce “math blocks” and anxiety. Part of the writing-to-learn method that the author used included writing step-by-step procedures for specific problem solving. The author also mentioned some motivational techniques to get students to encourage participation in the writing activities. One idea he mentioned was presenting actual evidence to students that the process works. For the first exam in this algebra class he required students to turn in “tickets” before being allowed to take the test. These “tickets” had to include step-by-step procedures for each type of problem they had solved. The tickets were not graded, but the teacher did separate them into two groups of good entries and bad entries. He then compared the test scores to the level of response handed in. He showed the students that everyone who turned in a “good” ticket happened to get a score higher than 80%, and everyone who turned in a “bad” ticket received less than 80%. This hardcore evidence seemed to convince students that the process was effective. I found this

study to be encouraging. I hoped going into this study that my students would also find the journaling experience to be a positive one. Although I found the “ticket” idea to be interesting, I did not implement this idea. Instead I kept it in my possible resources as an idea to use in case my students needed additional motivation.

Powell (1997) believed that student writing about their feelings and mathematical ideas it can be a vehicle for teachers and students to “examine, reflect deeply on and respond to their mathematical thinking” (p. 21). In this article, Powell examined the idea of journals and learning logs, tried to illustrate their usefulness and how essential writing is in a math classroom, and he also examined the idea of multiple-entry logs. Powell gave several examples illustrating the various benefits of journal writing. He believed that “writing forces students to reflect on mathematical experiences and that as students examine their written reflections, writing leads them to reflect on their ideas critically” (p. 23). He also believed that this would help students become more confident in their understanding and more engaged with mathematics. This process of reflecting and then critically reflecting again can be accomplished with what Powel calls multiple-entry logs. The basic idea here is to provide space to go back and re-reflect on an earlier entry. This was an idea that I implemented in my study. I encouraged students to look back at my responses and respond again. Although not all my students took this opportunity, many of them did improve or

clarify their responses. I also found that many students found that journals forced them to reflect on their own understanding, to really know whether or not they understood the concept.

Pugalee (2001) attempted to answer the question, does student writing about mathematical solving processes show evidence of a metacognitive framework? The researchers conducted a qualitative analysis of twenty ninth-grade algebra students' writings. Each day for six days, students were given a problem ranging from easy to difficult. Students had ten minutes to complete the writing activity, but were allowed extra time as needed. Students were prepared for the study by undergoing three months of writing once per week. Ten days before the study students completed a problem each day, and the following day received the teacher's feedback. This research suggested that metacognitive frameworks were evident in students' writings about their problem solving practice. Students demonstrated their mathematical reasoning through their writing. This study also supported the use of student writing as a form of assessment to be used by the teacher to determine how students think and learn mathematics. I also hoped to see evidence of metacognition through my students' writing.

Kathleen P. Chapman (1996) was a high school algebra teacher, who was frustrated by her students' lack of response in class. In an effort to find out what

they were thinking she began to implement journals, hoping to “awaken their thinking” (p. 588). Initially she did not have students write on a regular basis because of the challenges of incorporating the journal into her content and the time spent responding to the journals. However, as she progressed she found that journals were not only “...extremely valuable for diagnosing and trouble shooting misconceptions,” they also helped her to revise her teaching strategies and improved rapport in her classes (p. 588). As a result of this finding, Chapman began to use journals twice a week. She found that journals provided an “excellent opportunity for building communication” between her and her students, and that journals opened up “...pathways that lead students to the world of thought-their own” (p. 590). This article was from the perspective of a fellow math teacher. Her findings helped to authenticate my own ideas of what journals might do for my classroom. Chapman offered a few examples of the writing prompts that she used. These added to my accumulated ideas of what I could use in my Trig/Pre-Calc class.

Barbara Dougherty (1996), another teacher researcher, used journal assignments in her eighth-grade algebra class almost every night as a part of homework. She created writing prompts to focus on what she considered to be the important math content. She also created prompts designed to have students explain the process behind their problem solving. Dougherty offered several examples of these prompts along with samples of student work. Although the

content was at an Algebra I level, I found the ideas to be applicable to Trig/Pre-Calc. I integrated her process prompt into my study in the form of what Carr (2002) called a “journal.” A specific example would be Journal #4, in which I ask students to explain their process through Journal #2. (See Appendix E.)

Mayer and Hillman (1996), both teacher researchers, offered their rationale as to why writing is important in a math classroom, suggested what teachers and students learn from the writing process, and provided actual samples of student work. According to their experience journals provide an opportunity for students to “... express their feelings about mathematics, reflect on what they have studied, and demonstrate prior knowledge of a future topic” (p. 423). Writing helped their students to think about and reflect on their problem solving process, appropriately apply mathematics to problems and use appropriate mathematical reasons for their steps. Students found that their logic became more focused as they wrote and developed a sense for the importance of communicating effectively. Mayer and Hillman also found that the journal writing allowed them to see on a regular basis what students knew and were able to do. Although they did not offer details on how they implemented the journals their findings once again helped to confirm my hopes.

Elliott (1996), a high school math teacher, began implementing writing in her classes after taking a writing class. She recommended using writing as a tool

to stimulate thought. She suggested that writing could be used to begin a discussion, be “recycled” for a later time or be initiated by a spontaneous class conversation (p. 92). Her students used journals to summarize the day’s lesson and to write about new concepts they were learning. Elliott called her tool a “learning log” which was kept in the classroom. She found that writing allowed her to reach students who normally struggled while at the same time bolstering the understanding of stronger students. This article offered another perspective on how journals might be used in my classroom. I decided that I would create some prompts designed to have students explain a recent concept discussed in class. One such example was Journal # 10. I also developed a journal based on students’ current, spontaneous questions. This was Journal #7. (See Appendix E.)

McIntosh and Draper (2001) offer several suggestions for implementing learning logs in a math class. They describe learning logs as a place where students should “reflect on what they are learning and learn while they are reflecting on what they are learning” (p. 554). They recommend that learning logs be implemented several times per week to keep students “in the habit of thinking about mathematics and communicating mathematically” (p. 554). They warn teachers that resistance may surface when attempting to introduce learning logs as a new idea. McIntosh and Draper emphasize that students need to know that the teacher is reading their journals. They suggest that teachers respond

either orally or in writing with positive feedback. They have found that students will write more when encouraged with positive commentary. The prompts offered in this article focused mostly on content, but they did include one that focused on students' attitudes toward mathematics. This research again suggested several positive outcomes that I might find when using journals in my classroom. It also helped me to decide that I needed to respond to each journal written by my students, and that I needed to use journals several times per week.

Nancy B. Williams and Brian D. Wynne (2000) decided to try journal writing in their Algebra II and Geometry classes after reading about the potential benefits and because they were looking for an alternative to the typical tests, quizzes and worksheets used in their classroom. They assigned journal writing twice each week, alternating between two forms they called affective and mathematical journals. Each week the journals were collected on a Friday and graded over the weekend. Later they opted to assign one journal per week. Students were given five to ten minutes to work on the journals, were not allowed to collaborate, but were encouraged to use class resources such as textbooks and notes. Students initially complained about the journals, but as the semester progressed the students opted to continue with them. As a result of their study Williams and Wynne made several recommendations to the teacher trying journaling for the first time. They recommended attempting journals with only one class initially, to decide ahead of time what the students would write, and to

make sure the journals related to the content being studied, not just used as a filler activity. They included several sample prompts that were helpful to me in creating my own prompts. Their caution about using the journal in only one class seemed to make sense to me as I decided to focus only on Trig/Pre-Calc for this study. Also, their difficulties over grading the journals helped to reinforce my notion that perhaps the journals should not be graded, and I decided that while I would respond to the journals I would not assign a grade to them.

Stephen BeMiller (1987) described how he uses journals in his math classroom in Toby Fulwiler's *The Journal Book*. BeMiller, over his vast teaching experience, discovered that students learn best when teaching others and felt that by writing, students were working in an explanatory mode. In his class, he required students to create what he called a workbook. This workbook contained several different types of writing including transactional writing and expressive writing. Transactional writing included writing which was specifically directed in class, as well as conceptual writing outside of class. Expressive writing was more personal, including feelings and thoughts. BeMiller included several sample prompts which gave me more ideas. BeMiller found that writing gave students the ability to assess their own learning, progress and difficulties, and gave himself the ability to monitor his students' academic and personal progress. He said, "writing is truly individualized instruction. In its expressive forms writing allows every student to explore, discover, connect, translate, and personalize knowledge" (p.

366). One of my main goals in this study was to find a way to individualize instruction, since I believe so strongly that learning is a one-on-one transaction. I found BeMiller's expressive writing to be fascinating, and although I did not explicitly design many expressive prompts I did decide to verbally encourage students to include their personal thoughts and feelings.

Quinn and Wilson (1997) designed a study to "determine current teacher beliefs and practices regarding the use of writing in the teaching of mathematics" (p. 15). Also the study attempted to determine teacher attitudes toward writing in a math class, what types of writing activities are used in math classes, what types of writing activities teachers believe are most important for use in a math class, and teacher interpretations on the advantages and disadvantages of writing in a math class. Five elementary, five middle schools and four high schools of various socioeconomic levels were given a questionnaire for this study. Among the teachers who actually returned the questionnaire, there existed enough variety to keep the study balanced. This study determined that teachers have a very favorable attitude about writing in a math classroom, but most of these teachers do not use writing activities in their classroom. Most teachers use writing activities less than once per week. The two major reasons teachers gave for not using writing were student writing ability (or lack of...) and time. Most teachers responded that they believed writing activities would benefit student learning. The authors of this study addressed some of these concerns and gave possible

answers for solving these dilemmas. They also emphasized the need to encourage change on this issue. I found this study to be unique in telling the story of what is really going on in most schools. Most of the other studies gave wonderful examples of the potential of writing in a math classroom, but failed to mention what is not going on in most classrooms. Based on this study I realized that more than likely most of my students would not have used journals or any form of writing in their previous math classes. I realized that I would probably be breaking new ground with my students.

Sebranek, Kemper and Mayer (2001) offer another perspective on classifying writing in a math classroom. Journal writing includes a variety of types of writing, which should be done on a regular basis. One type of journal is the learning log. They describe the learning log as a notebook, which would include a variety of types of writing. The learning log, according to them, is a place to explore thoughts. Another type of journal is the dialogue journal in which the writer and a partner carry out a conversation in writing. They also suggested that journals writing be separated from the activities that are graded in class. They emphasized that it should be free from the weight of grades and other expectations. I found this piece to be helpful in offering another form of classification of writing in a math classroom. Their dialogue journal seemed to be very similar to the dialogue journal used by Gordon and Macinnis (1993). I decided instead of having a separate journal called the dialogue journal that all of

my journals would be considered dialogue journals in which the students and I would communicate with each other. This piece also included a few sample prompts from a variety of subjects that were helpful.

RESEARCH DESIGN

In order to accomplish these goals, I began by reading a variety of studies involving journaling in a math classroom. Based on these studies I was able to develop a plan for my action research. I decided to give two to three prompts per week to which students would need to respond. Gordon and Macinnis (1993) gave their students 10-15 minutes each day to complete their journal assignment. Their idea was to keep the journals as a routine part of the classroom so that students would become comfortable using them as a communication tool. At first, I thought this sounded good for my own classroom. However, I quickly discovered that there were days that we could not get to the journal, and trying to squeeze it in was ineffective. My students gave me feedback by journal 4 that suggested we were trying to do too many journals. As the study progressed we focused on one journal per week; however, we might revisit it two to three times that week. Typically we would start out writing individually, then work in small groups on the journals the following day and finally finish the journal in a class discussion on the third. I initially thought of using small groups with my journal

activities after reading Aspinwall and Miller (1997), who used group work so that students could practice communicating verbally as well as in written form. I found that my students enjoyed the support of their classmates, especially on difficult prompts. Johanning (2000) also used group work as an opportunity for students to discuss and evaluate their approach to the problem.

Throughout my study I attempted to give specific instructions along with the journal prompts. In these instructions I consistently reminded students to try their best, to be completely honest. I often encouraged students to feel free to write any other thoughts in their journal that they felt might be helpful even if these comments were not directly related to the journal prompt.

I needed to decide before my study began, whether or not to grade the journal or to include it somehow in the evaluation of my students. This was the most difficult decision for me to make. Gordon and Macinnis (1993) found that students were willing to share their difficulties because the journals were not used as an evaluative device. I knew going into the study that I would in all likelihood be teaching extremely grade-conscious students. I felt strongly that my students would already feel pressure to answer the prompt “correctly” simply because I would be reading it. I didn’t want to add the pressure of a grade to this. In the end, I do believe that this worked well for my class. I’m sure some of my students would have appreciated extra credit for the journals, but I feel strongly that this may have diminished the honesty with which my students wrote.

At this point in my design process, I needed to decide what types of prompts to create. Carr (2002) describes two types of writing prompts, which she calls journals and learning-logs. According to Carr, journals are open-ended. They allow for feelings, opinions and personal experiences. They allow students to show misconceptions, biases, questions and difficulties that they may have. Learning-logs, on the other hand, are more objective. In these prompts, students respond to a question or problem related to what they are currently learning. Gordon and Macinnis (1993) presented two similar ideas, which they call prompted writing and open-ended writing. They also introduced the idea of a spontaneous journal entry designed by the class discussion. Johanning (2000) used only one type of prompt in his study. Students were required to respond to non-routine problems by writing detailed descriptions of their approach to the problems. Powell (1997) introduced the idea of the multiple-entry log. In this type of writing activity students were asked to revisit previous entries and reflect on their earlier response. Each of these articles also included sample prompts from which I was able to glean ideas for creating my own prompts. I decided to include all of these ideas in my prompts. I wanted to have students respond to non-routine problems, to more objective prompts related to the content and at the same time allow for frustrations and feelings to come out. I also wanted to encourage students to revisit their previous responses and reflect on them. I did not differentiate between these types of prompts for my students. I simply created

a wide variety of prompts and called them journals. Several of my prompts specifically asked students to relate their feelings about the journals or whatever they felt like sharing. I also encouraged them on a regular basis to feel free to include these thoughts within their journals. Many of my students opted to do so.

To clarify specifically how I classified the journal prompts which I created I attempted to divide them into a few main categories. Again, this classification was not used in my classroom. I referred to all entries simply as “journals” when discussing them with my students. For the purpose of this thesis however, I have divided my entries into three main categories. The first category is that of the “learning logs.” This was intended to match Carr’s (2002) definition of a learning log as a prompt designed to specifically involve the current content of the classroom. These entries required students to respond to a prompt which was more objective. These prompts were usually application problem where students would apply the knowledge learned in class to a problem situation. The prompts I designed that matched this category were Prompt #5, 11, 12, and 13. (See Appendix E for a listing of all prompts.)

The second category I created was that of the open-ended journal. Again, I chose to model this after Carr’s (2002) description of a journal as being more open-ended, allowing for freer thought, creativity and student individuality. These prompts were still related to the content, but were more subjective. For most of these prompts student were required to explain an abstract concept to

someone else using whatever means they felt necessary. Prompts fitting this category included 1, 3, 6, 9, and 16.

Another category that I used was the collaborative/spontaneous journal. This category matched Carr's (2002) description of a journal, as it was more open-ended, but contained an entirely different element. This journal was created from a spontaneous need that arose in my classroom. In an effort to respond specifically to current questions I had students submit questions that were later synthesized into a journal prompt. Another adaptation of this type of journal required students to collaboratively create an application problem. I labeled Prompt #7 and #15 as collaborative/spontaneous as a combination of my own idea and Gordon and Macinnis' (1993) definition of a spontaneous journal.

Finally, my last category the review learning log combined Carr's (2002) definition of a learning log with the more specific element of reviewing the content from a unit of study. Prompt #8 and #10 fit this category. The reader should be aware that all of my prompts were created to meet the needs of my students as learners throughout the semester. Not all of my prompts fit neatly into these separate categories. Nor were they created specifically to do so. In addition, my categories were not created to be entirely distinct. A prompt that overlaps categories might certainly be created. These categories were assigned after the fact in order to highlight the differences between my prompts. Whenever

a prompt had a characteristic worthy of distinction from the other prompts I felt that it deserved its own category.

Several of the studies on journaling that I examined also mentioned the teacher responding to the students' journals. Gordon and Macinnis (1993) called their journals "dialogue journals" because they wanted the journal to be a place for communication between the students and the teacher. I felt that in order to encourage this communication on a regular basis, I needed to respond to each journal that my students wrote. I responded by commenting on what they wrote, answering a question that they posed, or by asking them a question. These responses varied from short comments like "That's a good idea!" to page long explanations of a concept that a student asked about. I frequently questioned students' thinking in order to encourage them to reflect again on what they had written. Along with my questioning, however, I always tried to include positive comments to encourage my students. I felt that my responses to each journal submitted would be the key to students taking the journals seriously. I felt that if my students could dialogue with me on a consistent basis they would find more value in the journals.

Collection of Data

Since my study is grounded in an action research methodology, I employed a variety of mostly qualitative data collection strategies, which I will be

describing here. Throughout my research I maintained a field log. This log was basically a collection of all my data. Some of the most vital pieces to go into this log were my field notes. According to Arhar, et. al (2001), field notes are “the direct observations of what is being said and done as well as impressions or hunches of the observer” (p. 140). This observation and reflection made an enormous contribution to my data. Within these field notes I wrote a variety of anecdotal records or “factual descriptions of incidents” (p. 146). Since most of my classroom activities required me to participate to some extent, most of these notes were participant observations in which I was “engaging to different degrees with the observed person or activity” (p. 137).

Another bulk of my data came from student work. The main concept of my study revolved around journal activities. In all sixteen journals were completed by twenty-eight students. Even with student absenteeism, this added up to a little less than 448 journal entries to for me to read and comment upon. Since these pieces came right from the students’ own words I believe that they contained the richest source of information about my students’ experiences in this study.

Initially, I had hoped to include two rounds of interviews in my data collection. However, after my first round of interviews, in which only two students participated, I decided to use questionnaires instead. I had my students complete an initial survey to get a feel for their math attitudes and success. Close

to the end of the study I asked my students to complete a questionnaire in which I attempted to use the projective technique described by Arhar, et. al (2001). A projective technique is simply an “open-ended type of self report” which allows for projection of “feelings, attitudes, beliefs and values” (p. 157). I designed several of my questions on the final questionnaire to allow for projection. (See Appendix B.)

Trustworthiness

According to Arhar, et. Al (2001), one important component to action research is to, “build in assurances for ourselves and for others that our professional judgments are trustworthy, credible, respectful, and reflective of our values” (p. 167). In attempting to build in these assurances I took several steps. Prior to my study, I learned as much as I was able about journaling by reading many of the major studies on this topic. Before my research could begin I gained the approval of the Human Subjects Internal Review Board at Moravian College by writing a proposal for research which was thoroughly analyzed for its ethical ramifications. I also informed my building principal of my study and gained his written consent. (See Appendix C.) Participants and their parents were informed, in detail, of my study and were required to give their written consent before I included them in my study. (See Appendix D.) In addition, pseudonyms have

been used throughout this study to ensure that students' identities have been protected.

According to Arhar, et. al (2001) another way to ensure trustworthiness is to triangulate the data collected. Triangulation is accomplished by "using multiple sources of data, multiple methods, even multiple theories" (p. 207). By including a variety of data collection methods, revisiting my field log, analyzing my observations and student work, gaining multiple perspectives through formal research and my peers, and by participant checking, or "taking data or interpretations back to the people most affected by it to ascertain their perspectives on what you have found," I was able to triangulate my research and verify my findings (p. 208).

Throughout my study I consulted my peer researchers, who were my group members in our research class, on my data and analysis. They were continually involved in my decision making process during the study. They acted as "devil's advocate" on ideas that I presented to them. My study was approximately fifteen weeks in duration, ensuring that it was prolonged enough for me to adequately explore my ideas. I also collected data on consistent/persistent basis. Through my analysis I consciously looked for negative cases that went against my prior assumptions. Also, I had participant checks through the surveys, interviews and journal entries throughout my study. I believe that prior knowledge of formal research, a variety of methodologies, peer

consultation, prolonged length of study, consistency in data collection, participant checks and looking for the negative case, as well as including actual artifacts of student work provided the system of checks and balances that I needed to complete a trustworthy, credible study.

MY RESEARCH STUDY

My Class

My Trigonometry/Pre-Calculus class consisted of 28 Caucasian, mostly middle/working class students. My school is located within a rural, traditionally farming community. Parents are generally supportive of teachers. Most of them hold the belief that students need to work for their grades. Parents, in general, do not put a huge amount of pressure on their students regarding grades. My students were generally used to success in mathematics. On an initial survey 22 out of 28 of them reported getting A's or B's in their previous math classes; 17 reported that they liked or loved math; 14 reported spending less than 30 minutes a day on math while the remaining 14 spend more than an hour on math; and 18 reported seeing math as being somewhat to important to their future, hence their enrollment in a Trig/Pre-Calc. Most students did not have a history of struggling in mathematics, seemed used to the status quo of school and being rewarded with the grade they want. As one of my Trig/Pre-Calc students recently reminded me, "You do realize that 90% of this class were grade freaks."

The 19 girls and 9 boys comprise the largest Trig/Pre-Calc class that I have ever taught. Trig/Pre-Calc classes in my building typically enroll around 20 students due to the difficult content. I have taught 11 of my 28 students in previous courses. This year's class consisted primarily of juniors with a few seniors as well. Almost all of my students were involved in extracurricular activities band, and the theatre production. My students were energetic, largely eager to please, and quite social. A typical class day began with five minutes of all out chatter, until I got them settled down. No seating chart change alleviated this situation since almost all of the students in the class knew and got along well with each other. Occasionally teasing sarcasm flowed back and forth between students as they egg each other on. Many of my students were eager to ask questions in class, and I would characterize many of them as aggressive sponges, since they preferred to be told exactly what they needed to know and would aggressively question until this was clear. We work within a block schedule, which means our class was 80 minutes per day for one semester. At the end of this second period class I was regularly drained, exhausted from this ordeal. What might sound to some teachers like an ideal situation could be frustrating for me; to teach students who were used to being spoon-fed their information. Many of our problems could not be solved by following a pre-determined series of steps, and my students often became frustrated and genuinely stressed out if they

couldn't figure something out right away. Their aggravation became quite audible during tough topic days.

Initial Feelings Toward Journaling

With the initial survey that I administered at the onset of the study, I discovered that out of my 28 students only one student recalled ever having used journals previously in a math class. However, only one student reported not having used journals in other classes, usually in English language arts class. I suspected that this would be the case going into this study, given my prior knowledge of my fellow math teachers and their methods. Before allowing the students to attempt to answer how they felt that journals might help in a math class, I needed to explain to them exactly what I meant by journaling. Since I was unable to give them an actual sample journal, I found that this was a difficult task.

In my initial explanation of my research agenda, I explained that we would be writing about problems or topics that would be directly related to the content that we would be studying. I tried to emphasize that I felt that these activities would be valuable to their learning experience, and that I wanted them to be completely honest in their feedback throughout the semester. Most of my students seemed to take my "presentation" of my research idea seriously. No one raised any objections, and only one student, Joseph, asked, "Will participating in this study compliment our grades?" I explained to the class that I would not be

grading the journals because I did not want students to feel the pressure to be “right” in the journals, but that it was my hope that the journals would help students to understand the content better, which would be reflected in their grades. I also explained that students had the right to withdraw from this study at any time without penalty. I gave each student parental consent letters which they and their parents signed. All of my students chose to participate.

On the initial survey, 24 students reported that they felt journals might be useful in a math class. I asked them to give suggestions about how journals might be helpful. Some of the responses that I received included, “I can imagine it would help me just cause I’m taking the time to go through and think about stuff that I would not normally think about.” Another student wrote, “It shows our thought process which will help us have a better understanding of what to do.” A third student said, “By reading through and understanding my own work, I can explain strategies to others more easily.” The majority of my students mentioned some possible positive contribution that journals could make in a math classroom. In some ways this might have seemed to make my task easier. Of course there was the response, “In my opinion, writing your thoughts out on paper is just a waste of time. As long as you understand your answer, question, how you get there, and show all your work including checking, then there is no way to get anything wrong.” Although only one student initially expressed this view on the survey, as we proceeded through the journal activities more students came to

articulate this position. As we progressed and I periodically checked for student feelings, I found that several students voiced the idea that journaling activities just take time away from “coverage” which prevented the discussion of more examples in class. Clearly, the pressure many teachers feel to cover a prescribed curriculum has trickled down into some students’ perceptions and expectations.

I didn’t wait long to introduce the first journal prompt. I suspected that it would take a few journals for my students to become comfortable with the process, so I wanted to expose them to these prompts right away. I initially intended to have journal activities several times per week. As the days went by, my students gave me feedback to suggest that this was too much, so I cut back our journaling to one prompt per week, revisiting each prompt two to three times before we would finish it completely. As I described earlier, I designed a variety of prompts combining the ideas of the learning-logs and journals described by Carr (2002), the dialogue journals and spontaneous journals used by Gordon and Macinnis (1993), the multiple-entry log introduced by Powell (1997) and the group work suggested by Aspinwall and Miller (1997). In this next section, I will share an example of each type of entry I used and explore the ways in which students responded.

Journal Activities**The Learning Log: Journal #5**

Carr (2002) would call this entry a learning-log. It was designed to be more objective, involving the topic we were studying, quadratic functions. It would also fit Johanning's (2000) descriptions of a non-routine problem.

Trig/Pre-Calc**Journal #5****Name:**

Sam, a local high school student, has his own lawn service business.

Suppose his weekly revenue, R , can be represented by the formula

$R = -p^2 + 50p - 125$, where p is the average price Sam charges for each lawn.

- A. Sketch a graph of the function R . Explain why it behaves like it does. Consider Sam's business.**
- B. Explain how Sam could earn \$400 dollars per week.**
- C. What price should Sam charge to earn the maximum revenue possible? What would that maximum revenue be? How did you find this answer?**
- D. Can Sam make his weekly revenue \$600? Why or why not? You may want to use the discriminant to help you explain your answer.**

This journal was completed over a few class days at the end of September when students had already been writing in their journals for over three weeks. During the week in which we worked on this journal we were learning about quadratic functions. I wanted students to have the opportunity to analyze a "real-life" scenario that could be represented by a quadratic function. We began this journal individually, just as we did most of our journals. I hoped that students would see what they could devise on their own before moving on to share their work and receive the support of their classmates. Students began this journal in

the final ten to fifteen minutes of the class period in which I introduced quadratic functions. The next day I began class with, "Let's go. Let's go. We need to get into groups quickly and finish up this journal." The screeching of chairs and desks into new positions mixed with the excited chatter of students talking about everything from the concert they attended the night before to the latest couple to break up. Cheryl interrupted my observations to ask me what would be on the next day's quiz. I responded by giving her a quick explanation about the quiz, and then I asked her to focus on the journal activity.

Meanwhile, Mae and her group were furiously working on long hand calculations and algebraic steps to find the roots and the vertex of the function. I thought about how this method might work to address the prompt, but I knew it would take a lot longer than using the calculator to trace the function. However, I found it to be an interesting strategy since they were allowed to use their calculators. I decided to ask the group if anyone remembered how to use the trace button on the calculator. I had introduced this feature to them in class during our lesson the previous day. I showed Mae how to trace the function and we discussed how the revenue would change as the price per lawn changed.

I should mention here that it was during this class period that I first started to participate actively in helping students through their journals. I had a difficult time deciding at first whether I should get involved since I wanted students to struggle to some extent and not just get "the answer." I was also concerned that

they would begin to rely too heavily on me, and I wanted my students to experience the thrill of figuring things out with the help of their peers. It was Dewey's (1938) remark that "...guidance given by the teacher to the exercise of pupils' intelligence is an aide to freedom, not a restriction upon it" which encouraged me to rethink my initial decision and participate more actively (p. 71). As the semester progressed it seemed to me that my guidance, when appropriately applied, was a necessary component to my students' learning through the journals.

I stopped at Dave and Michael's group next. As usual, they seemed to be ahead of their peers. They had finished the problem on their own the day before and were now discussing the quiz. Throughout this study Dave and Michael frequently finished journals ahead of time. Their journals usually contained the unique solutions that most other members of the class would not entertain. These two students remained top performers throughout my period of inquiry.

As I checked students' progress, I found that several other groups had forgotten about the trace key on their calculator as well. Meredith's group seemed to be having a difficult time explaining how to use the calculator's graphing and trace functions to her. I stepped in and showed Meredith how to find the maximum on the calculator step by step. Because she seemed to have a difficult time at first making the connection between the graph and the practical application of the problem, I also needed to explain that the y-values were the

revenue and the x-values were the price charged. She didn't seem to understand how I, or her group members, could know that the y-values represented the revenue and the x-values the price charged. Finally, a group member explained that the variables were defined in the problem.

As I made my way to Cheryl's group, she was just erasing her answer of 15 lawns for part B. She told me that her group had explained to her that it had to be 35 lawns. I asked her why she had given up so easily on her answer, and she told me that she wasn't sure. I said, "Don't let your group persuade you without at least a little debate, Cheryl."

"Okay, guys, why won't 15 work?" Cheryl turned back to her group with renewed confidence. "Well, 35 is better because it's more," a group member offered. "Actually guys, either 15 or 35 work," said Loraine who was looking at her graphing calculator. "And 15 would actually be 'better' because then he could mow less lawns and make the same amount of money," Cheryl countered. The group had realized that either 15 or 35 would match the amount of money the question required, and Cheryl realized that mowing fewer lawns to make the same money would actually be a better choice.

I included several other journal prompts, which were similar to this journal. One of these is Journal #2: The Helicopter Problem that I discuss in detail on page 43. Some of the other prompts which were similar include the following:

Trig/Pre-Calc

Journal #11

Name:

Students in a mathematics class were given an exam and then tested monthly with an equivalent exam. The average score was given by the "Human Memory Model"

$$f(t) = 80 - 17 \log_{10}(t + 1), \quad 0 \leq t \leq 12 \text{ where } t \text{ is the time in months.}$$

1. What was the average score on the original exam? ($t = 0$).
2. What was the average score after 4 months?
3. What was the average score after 10 months?
4. How many months will it take for the average score to decrease to 50? Explain two methods of finding this answer.
5. Consider the graph of this function. Will the students forget more quickly soon after the test or as time passes? Explain your reasoning.

Adapted from a question in our text, Larson (2001), this prompt was given later in the semester when we were studying logarithmic functions. My rationale was that it gave the students an opportunity to use a logarithmic function in a practical context, but still required them to understand the behavior of the function.

Trig/Pre-Calc

Journal #12

Name:

Col. Mustard discovered to be deceased in the drawing room by Professor Plum at 8:00am. (They think it was the candlestick that did him in!) If Professor Plum found his body temperature to be 75 degrees at 8:30 am, use the following formula to estimate the time of Col. Mustard's untimely

demise. $t = -2.5 \ln \frac{T - 70}{98.6 - 70}$ where T is the temperature of the

deceased and t is the time in hours elapsed since the time of death.

- A. What time did Col. Mustard die?
- B. Sketch the graph of this function.
- C. Explain the graph's end behavior (on both ends...)

My rationale for this prompt was similar to the last. Again, the prompt gave a practical context, although somewhat fantasy, which required students to apply the function and at the same time explain the behavior of the function within a specific context. The function in this prompt was taken from Larson (2001).

Trig/Pre-Calc

Journal #13

Name:

The numbers y (in millions) of vinyl single records sold in the United States in the years 1984 through 1997 are listed below. The data is given as ordered pairs of the form (t, y) , where t is the year, with $t = 4$ representing 1984. Create a scatter plot of the data. Decide which type of model best fits this data. Then find the model. Write a paragraph explaining why you think the model you chose is a good fit to the data.

$(4, 131.5), (5, 120.7), (6, 93.9), (7, 82.0), (8, 65.6), (9, 36.6), (10, 27.6), (11, 22.0), (12, 19.8), (13, 15.1), (14, 11.7), (15, 10.2), (16, 10.1), (17, 7.5)$

This was a prompt, which I found in our text, Larson (2001). It required students to use graphing calculators to find the functional model which best fits the real-life data. Students needed to explain their reasoning when choosing one model over another.

The Open-Ended Journal: Journal #6

Students completed Journal #6 in class during the first week of October. I actually found this prompt in our textbook (Larson, 2001, p. 155). We were studying polynomial functions at the time, and I felt that this would require students to explain the potentially abstract concept of the end behavior of odd and even polynomial functions. This would fit more under Carr's (2002) description

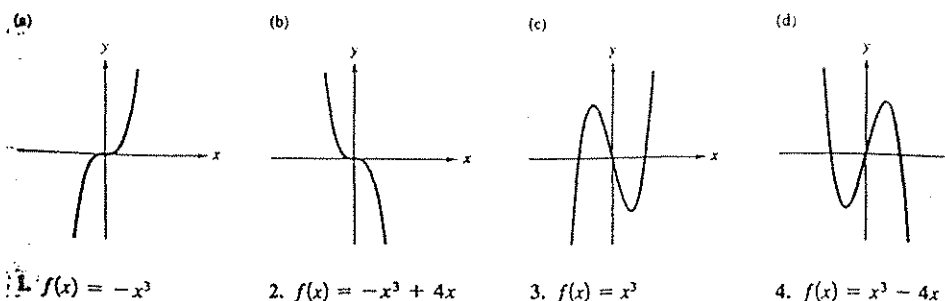
of a “journal” because it was definitely more open-ended than the previous entry had been. Students were able, for the most part, to complete this journal on their own without the help of their classmates. As with most of our journals, we discussed their answers at the end of our writing session. I was able to capture some observations of the individual writing time and the group discussion, which followed.

Trig/Pre-Calc

Journal #6

Name:

The graph of cubic polynomials can be categorized according to the four basic shapes below. Match the graph of each function with one of the basic shapes and write a short paragraph describing how you reached your conclusion. Is it possible for a polynomial of odd degree to have no real zeros? Explain.



The students worked quietly on their journals for about fifteen minutes.

Nearing the end of this allotted time, I noticed that Karla and Cheryl placed their heads down on their desks, appearing to nap. Helen asked me if she could have a calculator to check to see if she was correct in her response to the prompt. Evelyn began responding in writing to a question that I asked her in response to a previous journal. Anna looked at her watch, and Derick started coloring on his

journal folder. By this time I decided to bring the class back to discuss the students' responses to the prompt.

We began by discussing which graph matched each function. Several students volunteered to explain why each particular function matched its respective graph. The question at the end of the prompt, "Is it possible for a polynomial of odd degree to have no real zeros?" started a fascinating conversation. I asked the class whether or not an odd function could have no real zeros, and Joel attempted to respond, "No, because one end goes up and the other goes down... I don't know how else to explain it." He seemed frustrated by his inability to articulate his explanation. Jessica chimed in, "It's because of the Leading Coefficient Tests. As x approaches infinity, y approaches negative infinity." "So Joel, does this make more sense? Do you see how Jessica had an easier time explaining because she used the new math terms?" I asked. Joel nodded, but Loraine looked puzzled as she raised her hand and asked, "But how do we know that every real root will be on the number line?" I responded, "That's a good question. Does anyone know the definition of a real number?" No one responded. I waited, but no one responded. With time running out and the bell about to ring, I gave in and answered my own question, "A real number is any number that can be represented on the number line, so by definition a real root will be on the number line." "Oooohhhhhh!!," Loraine exclaimed, looking as if a light bulb had just turned on. Michael wanted to return to the original

question with another possible scenario to consider so he asked, “What if the exponent is negative, though?” I questioned again, this time asking, “What’s the definition of a polynomial function?” Michael shrugged, and once again with time ticking away, I answered, “By definition the exponent of a polynomial function is a positive whole number. If the exponent were negative the function would no longer be a polynomial, but it would be a rational function, which is a different case.” Michael nodded, “Oh that’s right.” I wrapped up our conversation by commenting, “Can everyone see how understanding the definitions of each word we are using becomes so important? For each situation we considered we needed to go back to understand what the question was really asking. What is a polynomial function? What is a real number? What is a root? If we can’t fully understand the question, we won’t be able to answer it.”

As we worked through this prompt students posed good questions for us to consider and as a result many seemed to get a lot out of this particular journal. While I initially believed that it might be a little too easy for them, many students later commented that they really enjoyed this journal. I suspect that this journal prompt proved to be within the zone of proximal development for most of my students, which may account for the fact that so many of my students seemed to value this journal and that we were able to have a conversation with so many teachable connections. Vygotsky (1978) said, “...an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a

variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers” (p. 90). I believe that this type of moment occurred during this journal activity and class discussion.

Some other open-ended prompts that I created include the following:

Trig/Pre-Calc Journal #1 Name:

Your best friend missed our last class. He doesn't understand what a function is. In your own words, explain to your friend what a function is. You may give examples as well.

Trig/Pre-Calc Journal #3 Name:

- A. Explain in your own words what a one-to-one function is. (You may use examples, graphs or mappings.)**
- B. Why does a function need to be one-to-one in order to have an inverse?**
- C. Your friend is having trouble finding the inverse of a function. Explain how to find the inverse of a function, using an example and giving your steps in a general way.**

Trig/Pre-Calc Journal #9 Name:

What is the difference between the functions:

$$f(x) = \frac{x+2}{x^2-4} \qquad \text{and} \qquad g(x) = \frac{1}{x-2} ???$$

Trig/Pre-Calc Journal#16 Name:

- 1. Explain the relationship that the graphs of cosine and sine have to each other...**
- 2. Explain the relationship that the graphs of tangent and cotangent have to each other...**

3. Explain the relationship that the graphs of sine and cosecant have to each other...

Each of these journals was designed to match the content we were studying at the time. While these prompts were similar in that they allowed for an open-ended response reflecting each student's individuality, each was slightly different. My rationale behind each of these prompts was to have students explain an abstract concept in their own words. It was my hope that by having them attempt to explain a concept that they otherwise might not have tried to verbalize they would need to think through it in more detail and they would be somewhat forced to realize whether or not they really understood the concept.

The Collaborative/Spontaneous Journal: Journal #7

This journal fit more along the lines of Gordon and Macinnis' (1993) spontaneous journal. A few days prior to this journal I asked students to list any questions that they had about the content we were currently discussing. At the time, we were studying rational functions and how to discover their real roots and imaginary roots. This tends to be one of the more challenging, abstract topics that we address. I told students ahead of time that I would compile their questions into a shorter list to use for our next journal prompt. Approximately ten students submitted questions, which I was able to synthesize into four common questions. Students worked individually on their choice among the four for ten to fifteen

minutes. I emphasized to them to focus on only what they felt they could answer and that we would discuss their responses afterward. I felt that this would give everyone an opportunity to answer a question, while having their own question answered by someone else. We had a group discussion at the end of class for another ten minutes, and many students shared their responses. We discussed each of the four questions, and I asked students to comment in their journal as to whether their original question had been answered. The following piece includes responses from four different students. Similar responses were shared in our class discussion. I chose these particular responses because I felt that they represented responses from students who seemed confident of their answers. These samples were also representative of the thorough responses which I received from students who were able to choose the particular question or questions that they felt comfortable answering.

Trig/Pre-Calc

Journal #7

Name:

What is the point of the lower and upper bound rule?

The point of the lower & upper bound rule is to eliminate some of the values that come up in the Rational Zero Test. When you find an upper bound all of the #'s above that can be canceled / + w/ a lower bound all the #'s below cancel out.

Can you put the lower and upper bound rule into simpler terms?

when putting a ^{possible} ~~positive~~ root through synthetic division:

→ if the answers at the bottom are all positive, you have an upper bound

→ if the answers are alternating, negative, positive, you have a lower bound.

Once you find a lower and upper bound do you have to keep looking for more?

You can find more by testing factors within your upper and lower bounds. So do this to keep narrowing down your list until you have found all the roots.

How do you find the lower and upper bounds??

When you synthetically divide a number, if you get all positive numbers as the quotient and you have a remainder, it is an upper bound. If you get negative and positive numbers alternating, then it is a lower bound.

I felt that this was a unique way to answer questions which perhaps would not have asked during class. Students were able to get their question answered in a non-threatening way by their peers. Having their peers answer their question may have also helped to encourage them that other students did understand the content and that it wasn't so impossible for them to grasp.

Journal fifteen also required more student collaboration. Although, we ran out of time before we were able to fully implement this journal, students wrote some creative responses after working together in groups.

Trig/Pre-Calc

Journal #15

Name:

Invent your own triangle trig problem in your group. Write a situation out. Include any diagrams if necessary. Be sure that your answers are reasonable given the real life scenario. Use this space as your exploration. Have one person in your group write out a clean copy of the problem. (This will be photocopied and given to other students to solve.) Include an answer key.

The Review Learning Log: Journal #8

Trig/Pre-Calc

Journal #8

Name:

Compile a list of all the various techniques for factoring a polynomial that we have talked about. Give examples if necessary. Discuss why the use of each technique is appropriate. (When would you use each technique?)

I designed this journal prompt to serve as a review before our test on polynomial functions. In our search for real and imaginary roots we used a number of techniques for factoring a polynomial depending upon its degree. This prompt required students to summarize those techniques and explain when each would be used. As with the last two prompt entries I described, this was completed individually and discussed as a class afterwards.

I gave students the option of using their journal as a resource when they took the unit test the following day, an idea suggested to me by my teacher research colleagues in my support group. Some students took advantage of this, and responded in the final survey that this gave them more confidence on the test. However, at least one student, Joseph, told me that he felt threatened by this opportunity. He felt that by allowing students to use the journal as a part of a formal assessment I was, in a way, assessing how well they had performed in the journal. This response surprised me, but I think that I understand where he was coming from. I am not sure how to resolve this conflict between different students' heartfelt opinions.

This journal was intended to be more open-ended and it did not call for an “answer.” Abby decided to use it to express her feelings and frustrations in this class. Initially when I first observed Abby she wasn’t writing anything, and I assumed that she had not been participating in the journal activity. Later I discovered that she had responded by writing her frustrations on the back of journal #7. However, based on this original observation I decided to go talk to her. I began by asking, “Abby, do you think you could at least try to write something?” Abby’s response surprised me, “I can’t try because I don’t understand anything. I don’t belong in this class. I’m only here because the guidance councilor suckered me into it.” I could see that she was near tears. “I’m glad that you are using the journal to let me know what your frustrations are. This is part of what I feel their purpose is. Let me try to help you get through this journal prompt.” I tried to encourage her. As I explained each type of factoring step by step, I discovered that Abby did know more than she thought she did. She understood the main concepts. I urged her to come in for help outside of class. She came in for only a few minutes the next day. We continued our conversation then. I asked, “We don’t have a whole lot of time before first period, but do you have any definite questions that you need answered?”

“No, I guess I’ll just see how it goes,” Abby shrugged.

“I think that you can do a lot better than you are doing. I really want to help you, but you do need to give me a little to work with.” I respond.

Abby nodded and sounding a little choked up pleads, “Whatever you do just please don’t kick me out.”

“Why would I kick you out?! I would never kick someone out for struggling in my class. I’m not sure what you mean?”

“I got kicked out of Trig/Pre-Calc last year because I was failing. That man does not like me.” From here we had to end our conversation because the bell was about to ring. I was quite surprised by Abby’s plea at the end of this conversation. She seemed frustrated and hopeless. In *Experience and Education*, Dewey (1938) asked the question, “How many students...were rendered callous to ideas, and how many lost the impetus to learn because of the way in which learning was experienced by them?” (p. 26). From my understanding of Abby’s previous experience, and my familiarity with the teacher she had the last year, I believe that Abby saw Trig/Pre-Calc as a intimidating course. She had experienced a “strong-arm” style of teacher-student relationship in the last Trig/Pre-Calc class. She did not find her previous teacher to be approachable, and she was beginning to find the content in my course totally overwhelming. She had “lost the impetus to learn” as a result of her series of negative experiences. She was caught in a pattern where she didn’t feel free to come to me for help because I was the “mean teacher” in her mind, and she was also unable to help herself out.

I believe that the conversation that we had as a result of this journal altered the course of Abby's experience in this course. She didn't pass her test that next day, although she came close. However, from this point on Abby performed significantly better. She began coming in for help, participating more in class and eventually pulled her grade up to a high 'C.'

The following piece includes Abby's earlier response to Journal #7 and her response on the reverse of this journal, which she wrote during our Journal #8 activity. Abby's response reveals her struggles and frustrations and her own admissions that she does understand more than she is at times willing to admit. Her venting not only helped to communicate her feelings to me, but it also seemed to make her feel better.

Trig/Pre-Calc

Journal #7

Name:

What is the point of the lower and upper bound rule?

I don't know what the lower and upper bound rule is. But if I had to guess what the point of it was, I'd say it was to find the highest and lowest parts of a function - that is like relative max & min though as I do not know.

Can you put the lower and upper bound rule into simpler terms?

No, I can not, sorry.

How do you find the lower and upper bounds??

I haven't the slightest clue... yeah I do. In the calculator somewhere there are things you can do. But I wouldn't know how to get to them, we're searching for it.

Once you find a lower and upper bound do you have to keep looking for more?

Sure, why not? The more the merrier, right?

I don't want to come in for no reason or want to waste my time. At the end of our "session" I still won't understand anything.

I'm NOT a math student. The real reason I'm in this class again is because I got suckered into it by a damn college coach who said it would look better on my transcripts. I took this class last year and got kicked out b/c I was so far gone. I can't do it. I don't even know how to do percents for god's sake.

I'm so frustrated. Our book gives crap for examples and definitions. I don't understand the wording. They throw in such crap that is irrelevant to the subject. I can't concentrate on anything. I sit here and write how I feel and I draw. I don't do my hw cuz I don't know how. Alright I'm stopping now b/c I feel better.

Another prompt that seemed to fit this category was journal ten. This journal is discussed in detail on page 47.

Trig/Pre-Calc Journal #10 Name:
Your younger sibling is taking Algebra II and cannot understand all the different types of asymptotes that the teacher has been talking about. Explain each type of asymptote, how to find each type, and what each asymptote will tell us about the function. Give examples and visual aides as necessary.

My Students

Each student responded somewhat differently on the journal activities. Abby, whose free response you have just read, found the journals most useful when she could use them to express her feelings, which I tried to encourage her to do, even if the prompt wasn't specifically designed for this. Other students approached the journals much like any other assignment, even though it was not graded. They did a "good" job in the sense that they answered what was asked and attempted to do their best at explaining. These students seemed to be motivated by their own intrinsic habits as high-achieving students and by the fact that they knew I would read their answer, and they didn't want to look as though they did not know. Meredith was one of these students, and she expressed the concern of looking "stupid" in the interview I had with her. Jessica was a similar student to Meredith in some respects, but each had a different perspective on the journal.

Meridith vs. Jessica

Meridith and Jessica were both high achieving students, used to getting A's in their math classes and seemingly comfortable with the status quo. Meridith was the kind of student who, in her own words, believed 'B' stands for "barely acceptable." She added that she gets "stressed out about everything." One morning Meridith came rushing into my room, dropped her books on a desk and proceeded to give a running monologue...

I think I've had a concussion or something for the last month. I can't remember anything and I keep doing really dumb things. I think something is really wrong with me. I was up last night writing a paper for English. I set my alarm for 1am, but when I woke up at 11pm, I thought it was morning, and I got up to write my paper. Then I realized it wasn't morning and I went to bed and woke up at 4. I seriously think I have something wrong with me. I'm going to fail this test. Do I have to take the test? Can I just go to the nurse 2nd period? If I go down for the first half of 2nd period and come back for the second half do I have to take the test????!!!!

Although Meridith was concerned about her grades, I often had conversations with her about the importance of the learning and understanding that should be reflected in the grade. In one conversation in which Meridith was

frustrated over her lack of understanding the concept I asked, “Meridith, maybe you are having difficulty here because you are used to being able to memorize and follow the steps. The problem is that I really can’t give you a neat set of steps to understand these concepts.”

“I know, but all my teachers told me to memorize and I always got good grades. Now I can’t remember anything from last year.” Meridith had become an expert at memorizing; however, the nature of our trig/pre-calc content did not lend itself to this approach. Most of our topics could not be broken down into steps and examples for each situation. Instead, they tended to be conceptual and abstract in which a genuine understanding could not be easily “bluffed” through a memorization approach.

Like Meridith, Jessica was quite concerned about grades, but she frequently suggested that if I didn’t play the game of school, as she was accustomed to playing it, then I wasn’t doing my job. She came rushing into my classroom on the second day of school barely containing her anger, “You don’t give us enough examples! I didn’t understand anything. How am I supposed to understand anything when you don’t give us enough examples?!”

Jessica seemed to be requesting a cookie-cutter set of examples and notes. The more time we spent in traditional instruction the happier Jessica seemed to be. Jessica was much more resistant to the journal activities. Although Jessica

and Meredith were similar in their concern about grades, they responded quite differently to the journal activities.

Meridith

"The journals frustrate me because I get stressed out when I do not know how to do/explain my thoughts! I like the fact that I can express my thoughts and questions on paper, which helps me see what I really do and do not understand. Like the prompt for the asymptotes ... That really helped because at first I wasn't sure what they were until I wrote about it. I had to think. If I really knew it I would be able to explain it to someone else. At first I hated them, but I just get frustrated about things I don't understand. But everything stresses me out, you know that. I think that they help overall."

Jessica

"I don't like the journals. We should not spend so much of our valuable math on these journal topics, so we can cover and understand the actual topic we are covering more. The journal problems are helpful as a whole, but it would be a whole lot more beneficial if you just gave us more examples in class. So I think the journals are a waste of time, just give us more examples in class."

I found these responses interesting because the students express similar concerns, both wanting to do well and becoming stressed out by grades. Both were successful in the past by using traditional memorization techniques, but Jessica was clearly resistant to the journals while Meredith was more accepting. Meredith did not pretend to be completely thrilled by the journals, admitting that they can frustrate her, but she seems to have seen the potential of this activity. Jessica, rather reluctantly, admitted that the journals were helpful, but she would much rather that I use the class time in more traditional teacher centered ways.

Brandon was a boy that I had two years previously in Algebra I. He had a mysterious air about him in the way that he responded to classroom discussions. Although he rarely participated in class, and even then only when called upon, I've always had the distinct feeling that he thought a lot about what was being said. Then again, he could have been out in day-dream land thinking about something totally different. In either case it was clearly apparent that Brandon did not work to his potential. Even back in Algebra I, I had a difficult time getting Brandon to do any homework at all. He would ace every exam without doing a single homework assignment. By eleventh grade this strategy had caught up with him, and he struggled throughout Trig/Pre-Calc. In the end, he failed Trig/Pre-Calc. Here is Brandon's response to a prompt in which I requested students to share their feelings about the journals.

Trig/Pre-Calc

Journal #14

Name:

What do you think about the journals so far? What would you change about them? What would you keep the same? How do they help you? How do they not help you?

I think journals are a way to further explore math and see it on different levels. Sometimes I don't want to explore math because I didn't really get the lesson or I'm just tired of doing math stuff, so I do the journals really quickly and don't produce quality work. When I really pay attention to them they're good, when I don't feel motivated to do them I don't get anything from them. There is nothing you can really change to make me want to do them it's just how I feel.

When the semester ended, Jessica, Kaitlyn (another student in the class) and I had a fascinating conversation about the course. Both girls described the semester as a challenge. They expressed a sense of accomplishment at “successfully” concluding the class. Jessica described the class as being a lot more difficult than what she was used to, but she felt as though she had learned to think differently as a result of the challenge. While she did not specifically mention the journal activities, I don’t believe that the challenge, which she described, would have been present in quite the same way without the journals. It was interesting to see this change in Jessica. Throughout the semester I had become accustomed to seeing Jessica stressed out and somewhat resentful toward me. Once the course was over she seemed grateful to have had the experience. If nothing else, I felt a lot better knowing that in the end Jessica found some value in these activities!

Brandon

Brandon was a striking contrast to Meridith and Jessica. He opted not to participate “fully” in the journal activities. By this I mean that he did not complete many entries, and although he wrote something for each entry he did not seem to take complete advantage of them. Perhaps if they had been graded, he might have participated more, but even this is doubtful since he did not complete many other assignments, which were graded.

This journal struck me as a genuine honest assessment on Brandon's part of what his issues were. He recognized the potential of the journal, realized that he made the decision to not fully participate, and admitted that there was little I could do to motivate him. The reason that this impressed me so much was the total honesty with which Brandon wrote. To me every student in Brandon's situation must come to this personal realization before making a change. I believe that if this realization had been drawn earlier in the semester I might have been able to intervene more, as I did with Abby.

Michael and the Helicopter Problem

Michael was like Meridith and Jessica in the sense that he was a "good" student, completing his assignments, coming prepared for class. However, Michael seemed to readily accept the challenge offered by the journal entries, without expressing any of Meridith and Jessica's stress and frustration. He did not seem to be bothered by the open-ended problems or problems that didn't work out nicely. Often he would find a unique way around an issue, as he demonstrated in the second journal prompt as well as in many subsequent prompts.

The helicopter problem, as my students referred to it throughout the rest of the semester, became the prime example mentioned in reference to journal frustration and stress. The prompt is as follows:

Trig/Pre-Calc

Journal Prompt #2

Name:

A helicopter has taken off from a hospital. The helicopter pad is located 300ft from the hospital. Let h represent the height of the helicopter. Let d represent the distance of the helicopter to the hospital.

A. Draw a diagram.

B. Express the height of the helicopter as a function of d . Explain how you came up with this function.

C. What would the height of the helicopter be if it were a distance of 200ft from the hospital? Why?

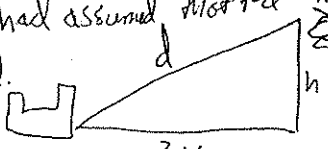
D. What is the domain of this function? Why?

The difficulty came initially with the drawing of the diagram. There were several interpretations to the problem. The simplest explanation would be to put the landing pad on a level surface with the hospital and draw the helicopter directly over the landing pad. However, some students came up with alternative locations for the helicopter and/or the landing pad. In the classroom conversation, which followed two days after we initially began the prompt, Michael shared his interpretation.

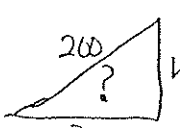
In the traditional set up of the problem, as mentioned above, 200ft could not logically be the distance from the hospital to the helicopter because the helicopter would have to go underground. Michael found a way around this issue, however, and he drew his diagram so that the hospital was uphill from the landing pad. This caused quite a stir in our classroom conversation. The “common sense” advocates argued that this was “stupid because who on earth would put a landing pad downhill from the hospital? They’d have to wheel the patients

uphill!" But the class had to admit that Michael had found an alternative solution, even if it had additional real world complications. Many of the students were quite frustrated by the open-ended-ness of this problem. Traditional students like Meredith and Jessica wanted "the solution." When they discovered that not only were different diagrams possible, but that each had a different function to match they became frustrated. Students like Michael, however, enjoyed these types of prompts, stating that he liked "...the journals because they make math seem less stale...[and]...help me to see how this stuff is actually used. This gives me hope that this stuff can be valuable to me in the future." From here on out I had two constituents to consider, students who preferred application problems and students who preferred concept explanation problems. The following piece is Michael's response to journal two.

At first I had assumed that the hospital and the pad were on level ground.



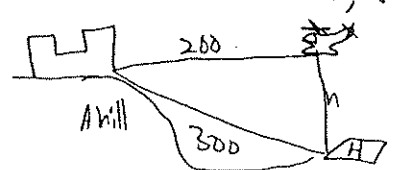
But Part C reveals that d is only 200ft. D was the hypotenuse, but it did not work because it would have to be > 300 ft. So, the 300ft side must be the hypotenuse.



With that, I was able to play with the Pythagorean theorem until I found the ans.

$$300^2 = 200^2 + h^2 \quad h^2 = 300^2 - 200^2$$

$$h^2 = 90000 - 40000 \quad h^2 = 50000$$

$$h = \sqrt{50,000} \text{ or } 223.$$


Mary's Change of Heart

Mary was pretty much what I would call an average student among my other high-achievers. She did not struggle to the level that Brandon and Abby did, and Mary is a good representative of the “invisible” students in my class, those that draw no attention to themselves by their stunning achievement or dismal failure. Initially Mary indicated the same frustration that Meridith and Jessica described. In journal four, I asked students to revisit journal two and describe their progress through it and their feelings about it. Journal two, as mentioned earlier, was frustrating for some students. I felt that by having the students explain their progress I would get a sense for how the group work and class discussion may have helped them, and I felt that some venting might help my students as well.

The following journal is Mary's response to journal four. Mary's response indicated that she was uncertain of herself through that process, and she seemed frustrated by the journals. This piece is the complete journal including my response to Mary's entry.

Journal 4

1st Day: I was frustrated b/c i had no idea how to even begin to approach the problem / equation. All i knew how to do was draw the diagram.

2nd Day: The group activity didn't really help that much b/c none of us really had an idea of what to do. The only thing we thought of to do was to use the Pythagorean theorem. *this is pretty significant strategy*

3rd Day: Going over the prompt in class helped me a little, but i still didn't completely understand it by the time we were done. I had an idea of what i had to do but even w/ the procedures laid out right in front of me, i still ~~had~~ had alot of trouble ~~compre~~ comprehending how to solve the problem.

Journals: I'm really not getting much out of these journal activities. I'm not trying to be antagonistic, but it seems like they cause ~~me more frustration~~ me more frustration than anything else. I don't feel like they're helping me understand anything.

I'm glad you are honest. Could they be frustrating because they are more challenging than just finding "the answer?"

This next entry is Mary's response to journal ten. This journal required students to explain the different processes for finding the asymptotes of a function. This journal was completed after we had spent several days discussing rational functions and their asymptotes. By the end of our study on this unit, I felt that for some students the methods for finding asymptotes had been jumbled, and I thought that this entry might help them sort out their ideas. As the journals progressed, Mary seemed to find more success in the journals. In this entry, Mary's response was more confident. She was thorough in her explanation and also included a note to me about her feelings regarding the journals.

Your younger sibling is taking Algebra II and cannot understand all the different types of asymptotes that the teacher has been talking about. Explain each type of asymptote, how to find each type, and what each asymptote will tell us about the function. Give examples and visual aides as necessary.

Types of Asymptotes:

Horizontal Asymptotes
Vertical Asymptotes
Slant Asymptotes

I like how you explained what HA & VA mean

→ Basically, ... an asymptote is a limit or boundary as to where a given part of a function can be graphed. The asymptote line is the imaginary line that the function approaches, but never actually touches. Once the x or y value gets to a certain point, it jumps to the other side of the asymptote to complete the function. always?

→ To find a horizontal asymptote, the numerator of the fn you are using must be set equal to 0 and solve for x . Then, to find the vert. asympt., the denominator must be set = 0. To find slant asymptote, the numerator must be divided by the denominator using long division.

$$2x = \frac{x^2 - 5x + 2}{x+3}$$

$$x = \frac{-5 \pm \sqrt{(5)^2 - 4(1)(2)}}{2(1)}$$

$$= \frac{-5 \pm \sqrt{25 - 8}}{2}$$

$$= \frac{-5 \pm \sqrt{17}}{2}$$

no real

$$x - 3 = 0$$

$$x = -3$$

$$\text{V.A.} = -3$$

Nice
Example!

S.A.

$$\begin{array}{r} x+2 \\ x+3 \overline{) x^2 + 5x + 8} \\ \underline{-(x^2 + 3x)} \\ 2x + 8 \\ \underline{-(2x + 6)} \\ 2 \end{array}$$

$$\text{S.A.} = x+2 + \frac{2}{x+3}$$

→ to complete the graph of the function, you must find the x & y intercepts. To find the x, set the whole fn = 0. To find the y, set x=0 (if/0). Then, plot @ least 1 point between each intercept & asymptote.

Mrs. Sotomayor:

→ Thanks for letting me know

I just wanted to let you know that @ the beginning of these journal activities, I thought they were really stupid & pointless. But I'm starting to see that they're helping me to understand the concepts better b/c they prompt me to think in a different way than just solving a problem & giving the answer.

Mary's feelings about the journals had changed over time. She seemed to develop a sense of their possible value. As I reviewed the final survey, which I gave at the end of my research, and compared it to earlier feedback, it seemed that many students expressed Mary's change of heart. The results of this survey are shared throughout my findings section.

MY FINDINGS

Methods of Analysis

Since my study was an action research study, it was continually evolving based on my perceptions of how the class was flowing and my analysis of the data already collected. So to some extent, I was analyzing my data throughout the study, making changes in my practice where I felt changes would benefit student learning. One of the ways in which this was accomplished was through the use of analytic memos, which I wrote throughout my study for a variety of reasons. These were reflective pieces in which I wrote about what I saw emerging as "patterns of behavior, words, key ideas, events." I also used the analytic memos to "record methodological dilemmas-what to try next..." (Arhar, 2001, p. 187). These memos helped me to understand the themes that seemed to be developing in my study and to analyze my own feelings and observations. For several of my analytic memos I attempted to reflect on my findings using the lenses of prominent educators, namely Dewey, Vygotsky, hooks and Friere.

According to Ely, et. al (1997) “Interpretations arise when patterns, themes, and issues are discerned in the data and when these findings are seen in relation so one another and against larger theoretical perspectives” (p. 160). In order to see these patterns I needed to organize my data by coding. Ely references Coffey and Atkinson as describing coding as “assigning tags or labels to the data, based on our concepts. Essentially, what we are doing is condensing the bulk of our data into analyzable units” (p. 165). I first created codes based on the ideas I saw emerging from my data. Then I re-read my log placing a code anywhere that I saw data reflecting that idea. To organize my codes further I grouped them according to larger categories, or bins. From these bins certain theme statements emerged. From a quantitative perspective I was also able to tally which codes appeared the most, giving me an idea of which themes were most prevalent in the data I had chosen to place in the field log.

From my coding and binning I was able to develop theme statements that emerged from my data collection. These were simple statements about the main ideas that occurred in my field log. Through these themes I was able to interpret my data and determine my findings. Finally, I reviewed the ‘larger theoretical perspectives’ of the research that I had already to contextualize my findings.

Findings

As I reviewed my field log and my codes I found several themes emerging. One of the themes, which I discovered early on, was that *implementing*

journals in a Trig/Pre-Calc class made of students previously unexposed to math journaling may not be a welcome change to all students. Aspinwall and Miller (1997), also found that their first semester calculus students initially resisted writing. They found that journaling was new for most students, and therefore a difficult task at first. Although my students were not freshmen in college, the course content in Trig/Pre-Calc is likely the most difficult my students have experienced to date. As I mentioned earlier, all but one of my students reported never having used journals in a math class before. And although not all of my students were as vocal in expressing their views as Jessica and Mary were, I believe that many of them initially would have preferred to ditch the journals and spend more time going over examples. I find it interesting that bell hooks (1994) says, "Students are much more willing to surrender their dependency on the banking system of education than are their teachers" (p. 40). Freire (1993) states that "[i]n the banking concept of education, knowledge is a gift bestowed by those who consider themselves knowledgeable upon those whom they consider to know nothing" (p. 72). In this case, my students resisted my attempts to change our classroom from a banking-style classroom into one in which they might learn more authentically. Many of my students had been trained over the years to rely solely on memorization. The fact that they had made it to Trig/Pre-Calc demonstrated that most of them had been successful by memorizing and

“banking” the information in their mind, and since this worked to get the grades, why change?

Freire (1993) talked about how oppressed people may not see the need or desire to become liberated. They become comfortable in their status as the oppressed. In many ways, this described my students perfectly. Like the oppressed, my students did not initially welcome the freedom of the journals, and they needed time to become accustomed to this new idea. What I attempted to do over this semester was to give students the opportunity to taste a new freedom and take new control over their learning. However, as Freire states, “Authentic liberation... is not another deposit to be made by men” (p. 79). My students needed to take hold of this freedom for themselves, and I believe that as the semester progressed many of my students began to rise to that challenge.

It was for the same challenge that another theme emerged from my research. This theme implied that *journals may increase math anxiety for students used to traditional teaching styles*. The word “frustrated” appeared countless times in feedback from a variety of students over the course of the semester. In my final survey math anxiety was the second most written about topic. One student who saw the journal activity as just another task felt that “they bring on more anxiety because they’re another sheet to complete.” Another student explained, “they might have slightly added to ‘math anxiety’ because this was something new for us.” The majority of students, though, who reported

frustration throughout the semester, mentioned that they were frustrated because the journals were challenging and because they had difficulty finding “the answer.” In his study of students in basic algebra classes, Lesnak (1989) found that the writing activities helped to reduce math anxiety. I wonder if Lesnak’s students were general enough to not be the type of students who worry as much about grades or “answers.” Perhaps his classes held a greater mix of students who were not successful in traditional math classes, and therefore felt relief through the alternative learning activity. In all likelihood, my students were probably much more inclined to feel anxiety at a change in the traditional math class than general algebra students. In addition, the content experienced in Trig/Pre-Calc was most likely more difficult than students had ever experienced, and this probably added to this feeling of anxiety.

Regardless, some students felt and expressed this anxiety. Several students mentioned, however, that group work associated with the journal helped to alleviate this frustration. Helen, an average student in my class, explained this in her fourteenth journal. While she admits that the journals can be frustrating, she explains that the group work helps because she can see that everyone has been struggling with the same feelings.

What do you think about the journals so far? What would you change about them? What would you keep the same? How do they help you? How do they not help you?

I do like the journals, and I feel that they help me greatly. Sometimes, I do have to admit, they frustrate me when I don't understand the question being asked, or I just can't come up with a solution. What helps me the most is when we break up into groups. When everyone shares their ideas, it becomes easier for me to understand, and maybe some of my ideas help them. Then, when you go over the situation with us we can realize that other groups may have been just as lost as we were. ☺

Can this be good?
- Thanks!

I must emphasize that while many of my students mentioned frustration, not all of them felt that the journals increased math anxiety. Several students pointed out that for them the journals actually helped to relieve anxiety. One student wrote in her survey, "They help by letting the student explain their frustrations to the teacher."

Many other students shared this opinion that increased communication had many benefits for them. In fact on the final survey, *increased communication between the teacher and the students was the most reported benefit to journaling in a Trig/Pre-Calc class*. Only one student felt that the journals "did not impact communication at all." Almost every other student reported that communication increase was an added benefit to having the journals. To emphasize the variety of responses that I received related to communication, I decided to compile a selection of quotes taken directly from students' surveys into a pastiche.

According to Ely, et. al (1997), a pastiche is made up of “separate pieces [which are stitched] together from the separate parts into a more meaningful whole (p. 96). This can be seen on the following page. To me it is evident from this piece that my students would agree with Mayher (1983) when he says that journals provide “... a valuable format for private teacher-student dialogue on what’s working well and what’s troubling the student” (p. 2).

"They are a great way to communicate how the student feels about the way the class is being taught. Through the journals a teacher can tell if an entire class is lost on a concept and she should re-teach it."

**"When I express my frustrations you reply.
I like that about them."**

"I like how the teacher responds and gives ideas/comments. I also like when the student can go back and correct those mistakes and/or reply back to the teacher."

"They help by showing each other our thoughts."

"It's easy to communicate with the teacher through the journals."

"Increased communication was probably the best part of the project. They allowed the teacher to follow the thought pattern of the student so they could get to the base of a developing problem."

"If we don't understand something, we can write down why and you can help us, so they help in communication."

"I feel they did impact our communication in a good way. Reading some of your comments lets me know you do care, and I need to hear positive comments every now and then, which you give."

"I have often found myself leaving you hints and comments that I might not have said to you in person."

"I have many questions, often, and so it is good to be able to waste less class time and still get them answered. Sometimes we understand each other better with a visual element involved."

"I think it's a good way for you to see what we do and don't understand and it makes me feel good when I get one back that has positive comments on it."

"You get to hear or see how we think because not everyone speaks and contributes in class because they are embarrassed or whatever it may be. And we get to hear what you think of our ideas."

"They help because when you write back it's one-on-one instead of you teaching the whole class you can focus on me."

I should also mention that from my perspective increased communication was also the single greatest aspect that journaling brought to my classroom. As a teacher, I am concerned about understanding each one of my students and being able to communicate one-on-one with them to help them learn. By choosing to reply to each one of their journals I found that I really could communicate with each student as an individual. Some students took greater advantage of this opportunity than did others, but each student had a chance for his or her voice to be heard. I found that through their responses I was also able to see much deeper into how each of my students thought. I believe as Dixon-Krouse (1996) suggests that journal writing is "...a means to learn what we can about those we teach" (p. 109). This window into my students' mathematical thinking would not have been possible without the journals.

Another powerful theme that emerged from this study was that *the journals allowed the teacher to gain a deeper understanding of students' mathematical thinking and allowed students to understand more of their own mathematical thinking*. I tried to capture their feelings related to this in the following patai poem which was created from quotes which I selected from students' responses to the final survey.

Thinking and Understanding

*The journal has made me just think more.
 Yesterday, I went to a ballet and I was thinking about the angle of the ballerina's leg to the floor and how that could be a triangle.
 I think outside the box now.
 Sometimes I do analyze stuff more than I normally would.
 Journals make me think on my own better.
 They have helped me look at math in a different way.
 It's a way to explore through your own individual thought process.
 I think more about my own thinking during journal activities.
 I have deeper insight into the 'why' questions, reasoning.
 I can express my thoughts and questions on paper, which helps me see what I really do and do not understand.
 I just find out if I really understand it or not.*

These responses indicated to me that many students found that the journals helped their mathematical thinking. I was surprised that the journals not only helped students to assess what they did and did not really know, but that some entries also encouraged further analytical thinking outside of class. This finding seemed to match other researchers' findings. Students in Johanning's (2000) study indicated that writing helped them to find their mistakes, to remember the problem and to understand the problem more. Powell (1997) agrees that writing in a math class can be a vehicle for teachers and students to "examine, reflect deeply on and respond to their mathematical thinking" (p. 23). He also believes that "writing forces students to reflect on mathematical experiences and that as students examine their written reflections, writing leads them to reflect on their ideas critically" (p. 23). Mayher (1983) suggests that, "The composing process is essentially a meaning-making process" (p. 36). Dixon-Krause (1996) says,

“Writing has an inestimable value in helping us learn about what we know...” (p. 109). I found that this was certainly true in my classroom, and my students seemed to report the same finding about their own experience with the journals.

As our semester progressed, I came to understand what I thought I already knew, namely that one size shoe does not fit all. A theme that repeated itself throughout the semester was that *some students may prefer one type of prompt, while others prefer another for different reasons. A variety of journal prompts to serve different purposes seemed to be the key.* Students seemed to fit into one of two categories, those who enjoyed the application prompts (like the helicopter problem, Col. Mustard problem, etc.), and those who enjoyed the open-ended conceptual prompts (like the rational asymptotes prompt, polynomial function prompt, etc.). Feelings about these prompts ran strongly for some students. One student wrote in her survey, “Applications...I hate them! They get me frustrated, I think I’ll never understand them and give up!” Other students like Luke, mentioned how much they enjoyed the applications.

Trig/Pre-Calc

Journal #14

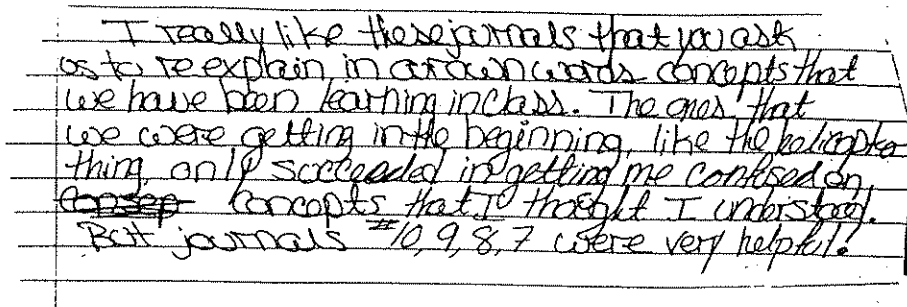
Name:

What do you think about the journals so far? What would you change about them? What would you keep the same? How do they help you? How do they not help you?

Journals = good
(better than PSSA)

I would make them more “real life”
situations when we can apply them.
They help reinforce the fundamentals of
the lesson

Loraine was a student who preferred the open-ended conceptual prompts, as she wrote on a piece of paper she put into her journal folder.



I really like these journals that you ask us to re-explain in our own words concepts that we have been learning in class. The ones that we were getting in the beginning, like the halompa thing, only scored and it's getting me confused on ~~concep~~ concepts that I thought I understood. But journals #10, 9, 8, 7 were very helpful!

Early on in my research design, I decided that I did not want to grade the students on their journals to avoid them feeling pressured to get the journals “right.” Gordon and Macinnis (1993) found that students were more willing to share their difficulties on topics because the journals were not graded. While I’m not sure if grading the journals would have discouraged my students from being totally honest about their difficulties, I do know that *students did not require extrinsic motivation (grades) to encourage them to participate fully in the journals.* Throughout the semester the majority of my students participated honestly and completely in all of the journals. As I re-examined the journals there may have been entries which were not equal to that particular student’s best performance, but this tended to fluctuate depending on the difficulty of the topic

or the frustration of the student, or even extraneous issues like the amount of time left for math homework after play rehearsal. Other students like Brandon seemed to lack motivation to participate in many activities regardless of whether these activities were graded or not. Overall, I had the impression that while some students would have liked to receive credit for their hard work, those same students would have felt a lot more anxiety if the work had been graded. Some students also gave me feedback that they appreciated the fact that they were not evaluated. Jane implied this in her fourteenth journal.

Trig/Pre-Calc

Journal #14

Name: _____

What do you think about the journals so far? What would you change about them? What would you keep the same? How do they help you? How do they not help you?

Like the journals, they give you some time to do work in class yourself and help you understand a little more because we ~~don't~~ do not have to do them and I think some people work better and sort through their options when there's no deadline there, they also help us explore different types of problems. When one doesn't get something they can voice in a small group what they did not understand and can help each other out by combining opinions

The most important theme for me when evaluating how much class time to devote to journals was the finding that *while not all of the students enjoyed journaling, most of them reported at least one positive effect that journaling had for them*. In the final survey, the overwhelming majority of students had at least one good thing to say about the journals. Even those who had been less than thrilled about the journals were neutral about most of the questions I asked. None of my students reported that the journals hurt them or hindered them in any significant way. Many of my students, like Melissa, expressed that journals were new to them and that it took them a while to warm up to the idea. Stephanie expressed this in Journal fourteen.

Trig/Pre-Calc

Journal #14

Name:

What do you think about the journals so far? What would you change about them? What would you keep the same? How do they help you? How do they not help you?

I guess the journals are slowly getting better. They're growing on me. It's good because they do actually stop and make us think about what we're ~~going~~^{doing}. I guess they do help me, but as of now I don't exactly know now. And I really don't think they hurt us at all.

Aspinwall and Miller (1997), also found that their students were reluctant at first, but over time their attitudes about writing in a math class improved. I feel

that if I had more time with these students, even the reluctant ones might eventually learn to appreciate how writing can help them think mathematically. Even as I conclude this study, I find that there are so many questions related to math journals that I would like to explore.

NEW QUESTIONS

I began this study with several goals. My overarching goal was simply to examine the experiences of my students while implementing journals in our math class. Although, I am not a veteran researcher I feel that I have captured the essence of this experience through the data I have collected and written about in this study. I also had several mini-goals that I initially thought might come out in my journey. I attempted to examine the impact that journaling would have on math anxiety, communication, critical thinking, metacognition and motivation.

Out of these I feel that I was most successful in discovering the positive link between journaling and communication. Critical thinking and metacognition were also obvious from students' journals. However, I did not focus my attention on classifying these data pieces. Math anxiety was also a running theme throughout my research. Students gave clear indication that they did feel anxiety in my classroom. What was not clear was whether this anxiety was strongly connected to the journals or merely aggravated due to the difficult content. Student motivation was a somewhat murky area in my study. My students were

highly motivated to begin with. I believe that this is why I did not focus as much on this issue. Motivation was simply not a problem in my class. In addition, my students, for the most part, fully participated in the journal activities throughout the study, so I did not feel the need to focus as much on motivation. Besides these initial goals I encountered a variety of new questions throughout my study.

One of the most prominent questions which was raised early on by my support group was “How can assessment be altered to reflect the journal activities?” In many ways, I felt completely unprepared to address that question. I believe I felt intimidated by it and not ready to face it or perhaps not ready to change my classroom *that* much yet. As I indicated earlier, I was taught in a traditional style in my mathematics classes. I guess I need baby steps to take me away from this approach.

In a small way, I did attempt to change my assessment in this study. At one point I allowed students to use their journals on a traditional test. I received mixed reaction on this. Some students appreciated this; others felt pressured by it. I hesitated to allow this for several reasons. First I felt that my students were so grade-conscious that the journal would become a large scale “cheat sheet.” This would distract from the real purpose of the journals. Second, since I was not meticulously “correcting” errors in students’ approaches or ideas, I was concerned that students would use incorrect assumptions from their journals on the test, thinking that these ideas had been sanctioned by me since I had read them.

Although we had class discussions in attempt to root out these false ideas, this did not guarantee that all of my students would go back and correct their previous assumptions.

In addition to this hesitant step of allowing students to use the journals on a test, I began to include more open-ended questions on my traditional assessments. These questions were more reflective of the open-ended application problems which students answered in their journals.

Perhaps the biggest change which I made to my assessment was in regard to our final exam. In the spirit of our “open dialogue” based class I decided to negotiate with students on our final exam. Students opted to include a project, which would be worth 30% of our total final exam grade. The entire project, including its overall grade value and scoring rubric, was designed by the students. A portion of the project grade was also decided by a self-assessment, which the students completed. This project, although not strictly related to the journal activities, was inspired by the communication, which resulted from the journal activities.

In spite of these changes I still feel strongly that more could be changed in effort to investigate this question. In no way would I like to turn the journals themselves into evaluative tools, but I feel that an alternative assessment might be developed to align more with the concept of the journals.

I would also like to further investigate the impact of group work on journaling. Once again, I felt ill prepared to thoroughly examine this concept during this action research study. In a way, this would have been chewing off more than I could handle at this point. Although I did use group work during this study, I did not carefully analyze the impact which group work had on students' journals. In my opinion, the question, "How does group collaboration impact students' math journals?" could be the focus for an entirely separate research study.

These questions and many others must be left for another round of the action research cycle. In the meantime, I have learned a great deal from my journey through action research this past semester. I have learned that it is not an easy task to implement a new and foreign idea such as math journals with a traditional group of students. I have learned that while some of my students had reservations, most of them felt that the journals contributed at least one positive benefit. For most of my students this positive benefit was increased communication between them and the teacher. Perhaps most importantly, and what I would like to pass on to the next action researcher who attempts this journey, is that the end result of a long and sometimes difficult process is a feeling of satisfaction that I have persevered in trying to become a better teacher and in trying to help my students become better learners.

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APPENDICES

Appendix A

Survey 1

1. How well (on average) have you done in your previous math classes?
(From A to F)

2. On a scale of 1 to 5, with 1 being the most negative and 5 being the most positive, indicate how you have perceived your math experience in the past.

3. On average, how much time do you spend studying/doing homework for your math class each night?

| | | | |
|------------|----------------|------|----------------|
| Not at all | 15 min. 30 min | 1 hr | more than 1hr. |
|------------|----------------|------|----------------|

4. How important do you feel that math is to your future?

| | | | |
|------------|---|----------|----------------|
| Not at all | | Somewhat | Very Important |
| 1 | 2 | 3 | 4 5 |

5. How important do you feel that your general education is to your future?

| | | | |
|------------|---|----------|----------------|
| Not at all | | Somewhat | Very Important |
| 1 | 2 | 3 | 4 5 |

6. Have you ever used journaling in a math class before? If so, how often?

7. Have you ever used journaling in any class before? If so, how often?

8. Whether you have ever used journals before or not, how do you think that writing in a math class might help you?

9. What helps you to learn the most in a math class? (Please make a distinction between what really helps you to learn and what is fun.)

10. Please comment on anything else that you think I should know to help you to learn in this class.

Appendix B**Survey 2**

Trig/Pre-Calc

Survey #2

1. What do you think about the journal activity?
2. What do you like about them?
3. What do you dislike about them?
4. How have they helped your or hindered your understanding of the math concepts taught in this course?
5. How do you feel that they impact communication between me (the teacher) and you (the student)?
6. Do you think that they help/hurt in alleviating math anxiety? If so how?
7. Have they personally helped/hurt you in this way? If so how?
8. How have the journals impacted your way of thinking mathematically?
9. Do you think more about your thinking as a result of the journal activities? How so? (ie. Do you think more about your own thinking only during journal activities or have you started thinking more about your own thinking outside of journal activities as well? Or none of the above!)
10. What would you recommend to change or keep the same about the journal activities if we were to start this class over again?

Appendix C

Principal Permission Letter

Any Area School District
 Any Road
 City, PA Zip

Dear Mr. Principal:

Currently, I am completing courses toward a Master's degree at Moravian College. This program has enabled me to remain informed of the most effective methods of teaching and to provide the best learning experience that I can for my students.

One of the requirements of Moravian's program is that I conduct a systematic study of my own teaching practices. The focus of my research this semester will be using journals in a trigonometry/pre-calculus class. I am excited to try out new ideas to promote this topic.

As part of this study, students will be asked to participate in journal activities, group work activities, surveys and possibly interviews. All data collected will be done anonymously. A student may choose at any time to not participate in this study. However, students may not choose to opt out of regular class activities. Journal activities and group work activities will be a part of regular class activities for participating and non-participating students. In no way will participation or non-participation in this study bear any influence on grades or assessment in my classroom.

In order to conduct this study I need your permission in writing. By signing this letter you are giving me permission to proceed with the study as described above. If you have any questions or concerns about my study please let me know.

Sincerely,

Susanna J. Sotomayor, Mathematics Teacher

I give permission for Susanna J. Sotomayor to conduct her thesis research study, Journaling in a Secondary Mathematics Classroom as described above.

 Principal, Any Area High School

 Date

Appendix D

Parental Consent Letter

Any Area School District
Any Road
City, PA Zip

Dear Parents/Guardian:

Currently, I am completing courses toward a Master's degree at Moravian College. This program has enabled me to remain informed of the most effective methods of teaching and to provide the best learning experience that I can for your son/daughter.

One of the requirements of Moravian's program is that I conduct a systematic study of my own teaching practices. The focus of my research this semester will be using journals in a trigonometry/pre-calculus class. I am excited to try out new ideas to promote this topic.

As part of this study, students will be asked to participate in journal activities, group work activities, surveys and possibly interviews. All data collected will be done anonymously. A student may choose at any time to not participate in this study. However, students may not choose to opt out of regular class activities. Journal activities and group work activities will be a part of regular class activities for participating and non-participating students. In no way will participation or non-participation in this study bear any influence on grades or assessment in my classroom.

If you have any questions or concerns about my in-class project call me at work at ###-###-#### ext. #### or email me at anymail@anyschool.com. Please sign the bottom portion of this letter and return it to school with your son/daughter. Thank you for your help.

Sincerely,

Susanna J. Sotomayor, Mathematics Teacher

Principal, AnyArea High School

I agree to allow my son/daughter to take part in this project. I understand that my son/daughter can stop participating at any time, and that involvement in this study will have no influence on grades.

Parent's Signature

Date

Student's Signature

Date

Appendix E

Journal Prompts

Trig/Pre-Calc

Journal #1

Your best friend missed our last class. He doesn't understand what a function is. In your own words, explain to your friend what a function is. You may give examples as well.

Trig/Pre-Calc

Journal #2

A helicopter has taken off from a hospital. The helicopter pad is located 300ft from the hospital. Let h represent the height of the helicopter. Let d represent the distance of the helicopter to the hospital.

- Draw a diagram.
- Express the height of the helicopter as a function of d . Explain how you came up with this function.
- What would the height of the helicopter be if it were a distance of 200ft from the hospital? Why?
- What is the domain of this function? Why?

Trig/Pre-Calc

Journal #3

- Explain in your own words what a one-to-one function is. (You may use examples, graphs or mappings.)
- Why does a function need to be one-to-one in order to have an inverse?
- Your friend is having trouble finding the inverse of a function. Explain how to find the inverse of a function, using an example and giving your steps in a general way.

Trig/Pre-Calc

Journal #4

In this prompt I verbally requested students to describe their process through Journal Prompt #2. I asked them to explain their progress on the journal through the three days that we worked on it in class.

Trig/Pre-Calc

Journal #5

Sam, a local high school student, has his own lawn service business. Suppose his weekly revenue, R , can be represented by the formula

$R = -p^2 + 50p - 125$, where p is the average price Sam charges for each lawn.

- A. Sketch a graph of the function R. Explain why it behaves like it does.
Consider Sam's business.
- B. Explain how Sam could earn \$400 dollars per week.
- C. What price should Sam charge to earn the maximum revenue possible?
- D. What would that maximum revenue be? How did you find this answer?
- E. Can Sam make his weekly revenue \$600? Why or why not? You may want to use the discriminant to help you explain your answer.

Trig/Pre-Calc

Journal #6

The graph of cubic polynomials can be categorized according to the four basic shapes below. Match the graph of each function with one of the basic shapes and write a short paragraph describing how you reached your conclusion. Is it possible for a polynomial of odd degree to have no real zeros? Explain.

Trig/Pre-Calc

Journal #7

What is the point of the lower and upper bound rule?

Can you put the lower and upper bound rule into simpler terms?

Once you find a lower and upper bound do you have to keep looking for more?

How do you find the lower and upper bounds?

Trig/Pre-Calc

Journal #8

Compile a list of all the various techniques for factoring a polynomial that we have talked about. Give examples if necessary. Discuss why the use of each technique is appropriate. (When would you use each technique?)

Trig/Pre-Calc

Journal #9

What is the difference between the functions:

$$f(x) = \frac{x+2}{x^2-4}$$

and

$$g(x) = \frac{1}{x-2} ???$$

Trig/Pre-Calc

Journal #10

Your younger sibling is taking Algebra II and cannot understand all the different types of asymptotes that the teacher has been talking about. Explain each type of asymptote, how to find each type, and what each asymptote will tell us about the function. Give examples and visual aides as necessary.

Trig/Pre-Calc**Journal #11**

Students in a mathematics class were given an exam and then tested monthly with an equivalent exam. The average score was given by the "Human Memory Model"

$$f(t) = 80 - 17\log_{10}(t+1), \quad 0 \leq t \leq 12 \text{ where } t \text{ is the time in months.}$$

1. What was the average score on the original exam? ($t = 0$).
2. What was the average score after 4 months?
3. What was the average score after 10 months?
4. How many months will it take for the average score to decrease to 50? Explain two methods of finding this answer.
5. Consider the graph of this function. Will the students forget more quickly soon after the test or as time passes? Explain your reasoning.

Trig/Pre-Calc**Journal #12**

Col. Mustard discovered to be deceased in the drawing room by Professor Plum at 8:00am. (They think it was the candlestick that did him in!) If Professor Plum found his body temperature to be 75 degrees at 8:30 am, use the following formula to estimate the time of Col. Mustard's untimely demise.

$$t = -2.5 \ln \frac{T - 70}{98.6 - 70} \text{ where } T \text{ is the temperature of the}$$

deceased and t is the time in hours elapsed since the time of death.

- A. What time did Col. Mustard die?
- B. Sketch the graph of this function.
- C. Explain the graph's end behavior (on both ends...)

Trig/Pre-Calc**Journal #13**

The numbers y (in millions) of vinyl single records sold in the United States in the years 1984 through 1997 are listed below. The data is given as ordered pairs of the form (t, y) , where t is the year, with $t = 4$ representing 1984. Create a scatter plot of the data. Decide which type of model best fits this data. Then find the model. Write a paragraph explaining why you think the model you chose is a good fit to the data.

(4, 131.5), (5, 120.7), (6, 93.9), (7, 82.0), (8, 65.6), (9, 36.6), (10, 27.6), (11, 22.0), (12, 19.8), (13, 15.1), (14, 11.7), (15, 10.2), (16, 10.1), (17, 7.5)

Trig/Pre-Calc**Journal #14**

What do you think about the journals so far? What would you change about them? What would you keep the same? How do they help you? How do they not help you?

Trig/Pre-Calc**Journal #15**

Invent your own triangle trig problem in your group. Write a situation out. Include any diagrams if necessary. Be sure that your answers are reasonable given the real life scenario. Use this space as your exploration. Have one person in your group write out a clean copy of the problem. (This will be photocopied and given to other students to solve.) Include an answer key.

Trig/Pre-Calc**Journal#16**

1. Explain the relationship that the graphs of cosine and sine have to each other...
2. Explain the relationship that the graphs of tangent and cotangent have to each other...
3. Explain the relationship that the graphs of sine and cosecant have to each other...