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# **Pre-Reading Mathematics Empowers Students**

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Math in the Middle Institute Partnership  
Action Research Project Report

in partial fulfillment of the MAT Degree  
Department of Mathematics  
University of Nebraska-Lincoln  
July 2007

## **Pre-Reading Mathematics Empowers Students**

### **Abstract**

In this action research study of my 8<sup>th</sup> grade mathematics classroom, I investigated the improvement of mathematical communication via assigning pre-reading material and requiring students to take notes prior to class discussions. I discovered that students became more active participants during classroom discussions and were able to produce work which illustrated their mathematical understanding. Teacher observations and improved quiz scores provide quantitative evidence, and student survey responses validate student communication. As a result of this research, I plan to assign pre-reading tasks and require students to take notes prior to class discussions with the goal to change classroom presentation from a teacher-centered approach to a student-led approach.

What exactly is the purpose of a mathematics textbook? Does it contain the questions for the assignment the teacher will expect done tomorrow? Could it be used to define mathematical vocabulary? Are there any examples listed that show the steps for solving the problems discussed in class today? Most mathematics teachers would answer in an affirmative manner to these questions, so why is it that most junior high mathematics students disagree with this line of thinking?

Most junior high mathematics students see their mathematics book as a place to go to get the questions assigned by their teacher, not as a resource full of mathematical information waiting to be read and studied and put to good use. I would like to see my students grab their mathematics book, study it section by section, take notes from it and ask questions when they don't understand what they have read.

As a teacher I have learned so much about mathematics through reading textbooks, working through example problems, and sharing ideas with my peers. A good textbook provides example problems worked out step by step, a glossary where mathematical vocabulary words are defined in a mathematical sense and reference pages identifying various symbols used throughout the textbook. I believe reading the material from the textbook is only the beginning of learning mathematics, and if students aren't reading, they are missing a vital part of the learning experience. If they read the mathematics, they will become more comfortable in mathematics classroom discussions and problem solving sessions. All of these experiences will contribute to an increased mathematical confidence where students will evolve from dependent learners requiring one-on-one teacher attention to independent deep-thinking mathematicians.

### **Problem Statement**

Students come to school with the preconceived idea that the teacher is the one and only resource they will use to learn the information required for class. They have been conditioned to come to class to get what they need, do what is assigned to them, and as they exit the classroom door, the learning stops until they enter the classroom again. Currently students come to mathematics class to have concepts taught to them. They believe the only way they will learn the mathematics is if the teacher “shows” them how to work through the problems.

Ideally students should be the leader of their own learning, using resources inside and outside of the classroom, not relying on the teacher to be their only source of information. So how does this learning cycle begin? It begins by reading about the material that is to be presented. Mathematics has its own set of definitions, rules to live by and procedures from which to work. Students need to start the learning process in mathematics by pre-reading the material before class discussions in order to have a base upon which to build.

Requiring students to do pre-reading in mathematics will provide students another way to experience the mathematics and make connections. The goal of this experience is to give students a base upon which to build, help them derive questions to interject during class discussions, and identify for them another resource to which they can refer.

### **Literature Review**

Step inside a mathematics classroom where a student is assigned a story problem. Soon after the teacher has assigned the problem, the student has returned to the teacher seeking assistance to which the teacher replies, “What is the problem asking?” The

student responds “I don’t know.” Still questioning the student, the teacher says, “What operation do you think you need to use?” and the student responds, “I don’t know.” The teacher looks at the student and asks, “Have you read the problem?” to which the student responds, “No.” The previous situation is an all too familiar scene today. The underlying problem here is students don’t want to read in mathematics class. They want to be told what to do and how to do it and become frustrated when they are required to repeat a task more than once. When given time to read material in the classroom, some students prefer to stare at the page and wait for the teacher to summarize the information for them and to show them the process necessary to solve the problems for the assignment. Society today has produced a generation that desires instant gratification, and reading mathematics requires translating, making connections, and thinking; this is not quite the instant process students desire.

Mathematics is a language that requires the use of vocabulary and symbols to translate problems from word form to symbolic form. Textbooks are commonly written in a concise manner using symbols and diagrams; so why don’t students want to read in mathematics? Mathematics textbooks are a different read as compared to a novel or a poem. Adams, an associate professor with a PhD of Instruction and Curriculum in Mathematics Education at the University of Florida, identifies reading in any content area as an integral part of a student’s school experience. Adams (2003) outlines how mathematics can be identified as a language, exemplifies the importance of teaching children to read mathematics and illustrates some suggested instructional strategies.

Mathematics is a language that people use to communicate, to solve problems, to engage in recreation, and to create works of art and mechanical tools. It is a language of words, numerals, and symbols that are at times interrelated and

interdependent and at other times disjointed and autonomous (Adams, 2003, p. 786).

Just as students are taught to read literature, they should be taught to read mathematics. A mathematics textbook requires a different reading style than that of a novel or history textbook. As mathematics teachers begin to require students to read and utilize their textbook as a resource, they will need to model the newly expected behavior for their students within the classroom. Adams (2003) supports the focus on reading instruction in the mathematics classroom for all students. She states that “weakness in their mathematics ability is often due in part to the obstacles they face in focusing on these symbols as they attempt to read the ‘language of mathematics’” (Adams, 2003, p. 786). As this process begins, reading in mathematics will be both foreign and frustrating to many students, but with patience and instruction from the teacher, all students can be guided toward independence in reading mathematics.

Teachers must be aware of students’ weaknesses in reading mathematics and be prepared to help students translate mathematical ideas into statements and mathematical sentences that are equivalent to the original problem. Epp, a professor of mathematical sciences at De Paul University, wrote an article for the 1999 NCTM Yearbook titled “The Language of Quantification in Mathematics Instruction.” She stressed the importance of students being able to correctly translate written statements into mathematical sentences. Epp states in her article that “students do not acquire these abilities spontaneously” (1999, p. 190). Thus, mathematics teachers must take ownership for instruction of not only mathematical concepts, but also the understanding of the mathematical language.

In their book, Barton and Heidema discussed a close relationship between reading and mathematics and identified the purpose for showing students how to read

mathematics. In addition to lacking the knowledge of how to read mathematics, vocabulary is also an obstacle for many students. Textbooks and articles often contain vocabulary that is unfamiliar and commonly has multiple meanings. Barton and Heidema (2002) show concern for students when they are given a vocabulary assignment in the mathematics classroom and their reference choice is the dictionary, where definitions may not provide a precise mathematical definition for students to use. Part of Adams' (2003) instructional focus is that words, terminology and vocabulary must be identified as the key components to understanding mathematical language.

Borasi, Siegel, Fonzi, and Smith (1998) studied four classrooms consisting of 82 students in 8<sup>th</sup> – 11<sup>th</sup> grade where they explored how instructional strategies from reading-education literature could support sense making and discussions in mathematics classrooms. In general, they found instructional practices where reading is incorporated can develop a community of practice. Borasi, Siegel, Fonzi, and Smith suggest the implementation of reading strategies and use of student experience have potential to increase student understanding and self-esteem in the mathematics classroom. “Instructional practices drawn from the field of reading can contribute more to the reform of mathematics instruction,” and “what students may gain from these texts can be considerably enhanced by the use of specific reading strategies” (1998, p. 302).

Where do teachers begin the implementation process for reading strategies in the mathematical classroom? According to Mary Lee Barton and Clair Heidema, “teachers can incorporate reading and learning strategies that help activate prior content knowledge, master vocabulary, and make sense of unfamiliar text styles” (Barton & Heidema, 2002, p. 24). Bratina, Associate Professor of Curriculum and Instruction, and

Leonard Lipkin, Professor of Mathematics and Statistics, from the University of North Florida, co-wrote an article with the purpose of recruiting teachers to utilize suggested techniques to improve communication in the mathematics classroom. Bratina and Lipkin have formulated ten recommendations for mathematics teachers to incorporate in their classrooms:

- 1) Include specific language arts activities in mathematics lessons,
- 2) Create instances for students to experience words in different contexts,
- 3) Practice and require precision in language usage,
- 4) Use equivalent expressions,
- 5) Make it a regular practice to assess students' abilities to communicate,
- 6) Provide time for students to practice the language,
- 7) De-emphasize ineffective strategies,
- 8) Applaud students' perseverance,
- 9) Confront eustress -- a good kind of stress, and
- 10) Be a wonderful role model (Bratina & Lipkin, 2003, p. 3-12).

Basically, researchers have found that communication between the mathematics student and the mathematics teacher must follow a developed set of language guidelines. When the teacher identifies student expectations and utilizes the guidelines as the role model in the classroom, the student is more apt to understand and to utilize the correct mathematical language. The National Council of Teachers of Mathematics supports the proper use of mathematical language in the *Principles and Standards for School Mathematics*. In the section of the Learning Principle it states, "Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge" (NCTM, 2000, p. 20).

An integral part of mathematical language development is the use of student experience and prior knowledge. Barton and Heidema (2002) contend that "each learner actively draws on prior knowledge and experience to make sense of new information" (p. 24). As students read mathematics, many rely on prior knowledge and previous experience for complete understanding of new concepts. Students then become frustrated

when new experiences involving thinking and making connections are required in order to make sense of the new concepts. Students bring knowledge and previous experiences to the classroom with them and must construct new knowledge and experiences while in the classroom in order for learning to occur.

Siegel, Borasi, Fonzi, Sanridge and Smith (1996) designed a research project involving two mathematics education researchers, a reading education researcher, and a group of secondary mathematics teachers. The purpose of the project was to center mathematics instruction around reading in order to engage students actively in the learning process. When students are given opportunities to share reading experiences teachers are “helping students make sense of mathematical concepts or procedures, seeing connections between mathematics and real life, developing broader views of mathematics, developing strategies for sharing information, and valuing students’ own ideas and those of others” (Siegel, Borasi, Fonzi, Sanridge & Smith, 1996, p. 75).

Implementing reading strategies in the classroom requires planning and purpose. “Teachers who purposely plan reading experiences to improve students’ literacy have greater success of accomplishing mathematics goals and developing students with better problem solving skills” (Bratina & Lipkin, 2003, p. 1).

Researchers Borasi, Siegel, Fonzi and Smith (1998) characterize reading as an active process where students must formulate new meaning from the text they read using prior knowledge and their worldly experiences as their guide. During their study these researchers focused on three reading strategies to develop new student experiences.

First was the Say Something strategy, based on the idea that student’s comprehension of the text is generated from dialog with the text and other readers. The second strategy, Cloning an Author, uses the process of reading and reflection via note cards producing a map of what the student had read. Sketch-to-

Stretch, the third strategy, incorporates the use of visual representation by the reader to record information from the reading into illustrations or acting out the text (Borasi et al., 1998).

The underlying theme beneath all three strategies is that students will share with their classmates what they have read. This sharing constitutes making a “new” experience for the student to utilize while in the process of understanding the new concept. Results from the research show that “each specific reading strategy not only offered students support for active thinking and reflection but also resulted in the production of symbolic representations or sharing of experiences that could be public and further negotiated as a class” (Borasi et al., 1998, p. 392).

“Learning with understanding is essential to enable students to solve the new kinds of problems they will inevitably face in the future” (NCTM, 2000). Reading is a basic necessity for understanding any subject area and for becoming a productive citizen in today’s society. In the mathematics classroom, reading is different from the reading that is expected in history or in literature, and for that reason mathematics teachers must take a vested interest in improving mathematical language literacy. The research shows that students need to be instructed how to read mathematics through the use of reading strategies and language arts activities. Each teacher must choose specific strategies and activities and provide students ample time to practice using them while reading the mathematics text. Teachers must also require proper use of mathematical language as the expected form of communication and present themselves as a role model for students. Life is full of experiences, and providing positive reading experiences for students in the mathematics classroom will further promote reading as a necessary life skill. As

Tomasenia Lott Adams (2003) said, “a knower of mathematics is a doer of mathematics, and a doer of mathematics is a reader of mathematics” (p. 795).

While Borasi, Siegel, Fonzi, and Smith (1998) studied the use of transactional reading strategies, this study will supplement transactional reading strategies with individualized reading and purposeful note taking. The project Borasi, Siegel, Fonzi, and Smith (1998) organized focused on 8<sup>th</sup>-11<sup>th</sup> grade students, and this study will be of only 8<sup>th</sup> grade students.

### **Purpose Statement**

The purpose of this study is to empower students to utilize mathematical language to communicate: verbally, in written form, and while reading mathematical material.

During the process of this action research, I will be investigating the effects of pre-reading mathematical materials on student learning. The following three questions were the basis upon which I organized my research. What impact does required pre-reading of textbook and/or supplemental material have on students’ mathematical understanding? Can daily note taking affect students’ mathematical communication? Will the increased use of mathematical language have an effect on student achievement?

As individual students are involved in the act of reading, some will see it as a difficult task, while others may be quite comfortable with it. The focus will be to encourage all students to utilize the reading and note taking as a mathematical experience designed to set them up for mathematical success.

## Method

To investigate my questions, I used six instruments to collect data: student interviews, student surveys, student journal prompts, teacher journal prompts, student assessment results, and video tapes of classroom discussions.

In March 2007, my class of 21 eighth graders was given a survey as the beginning phase of the study (see Appendix B). Prior to beginning the study, my students had been exposed to note taking and reading mathematics, mainly during class activities. As this study progressed, students were assigned to pre-read sections from their textbook and take notes prior to class discussions. Each student was required to use a composition notebook, provided for them, in which to take notes prior to class and during class. The day after pre-reading activities had been assigned class discussions were to be video taped. Some difficulty was encountered, and only two class discussions were taped. The results from the video tapes were not as useful as I had expected they would be during my data analysis.

During each week of the study students were given different journal prompts (Appendix C) to respond to in their composition notebook, and I also kept a journal as well (Appendix D). At the midpoint of the study, a colleague assisted me in randomly choosing four students to personally interview about their experiences. Interview questions are shown in Appendix A. My intent was to interview each student personally and tape record their responses. Two of my interviews went well, and the other two ended up being short response answers the students wrote out during their study halls because interviewing them face-to-face became impossible due to bussing and personal scheduling.

Upon completion of the study, student assessments were reviewed using pre- and post-study quiz and test responses. I also compared first semester grades to second semester grades, to see if student achievement had been affected. During the last week of school my students were surveyed again to finalize the project. Results from both surveys have been compared to identify a change in student opinion.

### **Findings**

Generally speaking, mathematics and reading are not usually found in the same sentence. When students are given a reading assignment during mathematics class, many boycott and wait for the teacher to “explain” what the assignment said. My first assertion is that requiring pre-reading of mathematical material does increase student comprehension and understanding. The data first show an increased student participation in pre-reading mathematical material from the results of question 1 from the student survey. At the beginning of the study 47% of the students agreed that they pre-read material, and at the end of the study 68% of the students agreed that they read about concepts in their mathematics book before the material was taught in class.

During student interviews, question number three asked the students whether they read through sections in their textbook requiring them to identify what they look at most. One student commented “Well, I’m not sure I read through them quite thoroughly enough to comprehend what I’m reading, I mostly look at the diagrams.” Another student said “Once in a while. I look at examples or steps on how to do it. I don’t read through a section because I know you will go over it in class. When reading is assigned, I do read it.” Other students commented that they don’t read the textbook unless it is assigned to them, and often they are unsure about the information they are reading.

Even though I commented earlier that my video tapes did not provide the evidence I was looking for, I did find that some student behaviors seen in the video tapes supported findings I had written in my journal. I noted in my journal that class discussions were much more productive and student-driven on the day after students had been assigned a pre-reading activity; the video tapes did confirm this improved student focus during class discussion. Several times in my journal I referred to the lesson requiring less time and that at least 75% of the students initiated involvement in the class discussion on their own without being prompted, meaning students had a better understanding of the material at the time of the class discussion. One comment I found interesting in my journal was, “Now questions are posed (by students), I can pose the questions back to the class and with reading background, several students know how to answer their peers’ questions” (Personal Journal, April 5, 2007). Before this study students relied on me, the teacher, to answer all of the questions, and now they are confident enough to guide the discussion and answer each others’ questions.

The second focus of this study was the effect of note taking on students’ mathematical understanding, and I assert that note taking during mathematics class is vital for student success. The pre- and post-study survey results from question number 5 show a consistent agreement that students utilize their notes to help them work through their mathematics assignment. At the beginning of the study 100% of the students agreed that notes were helpful, and at the end of the study 95% agreed. The change in results may reflect comments students made during student interviews. One student stated “Sometimes I get confused, when the para-educator tells me something and then you explain it in a whole different way.” Other students’ comments related to the idea that the

book and the notes from the class discussion don't always show the same steps or explain ideas in the same manner, which can be confusing. So as students increased using their book as a resource, some may have found their notes were not as useful as before. As I observed students' composition notebooks where they kept their notes, I found as the project progressed, many of my students were taking notes on their own before the class discussion and then highlighting and adding to notes during the discussion. One student commented during an interview "I like it when I have notes before we talk about stuff in class. I can pay attention better if I don't have to write down so much."

Mathematical language is a key component to the communication in the mathematics classroom. My final assertion is that students who understand what the mathematics is saying will be successful, and the only way to understand the mathematics is to practice it. All four of the students I interviewed mentioned that as they began working on an assignment, they found the directions to be confusing. Only when we took time during class to "walk" through the expectations of the homework did they understand how to get started. One student commented "Homework "walks" help us see what we are doing in that section or make sure we know what the directions are saying, which helps us to know what to use for pi -- the symbol or 3.14." In my journal I noted "students have fewer questions when I give a homework assignment if we take the time as a class to "break down" the directions and relate the practice problems to example problems."

At the beginning of this study students most often attempted quizzes without reading the directions. They would jump in and just do what they thought they needed to do, often writing down only answers. At the end of the study, students were actually

reading and following directions during quizzes and completing each of the steps required. The class average quiz grade for third quarter, prior to the study, was 78%. In comparison, the class average quiz grade for fourth quarter, after the study was completed, was 83%. As I reviewed student work, homework assignments and quizzes, I observed students showing their work, using the procedural steps shown in the textbook and illustrated during class discussions. I also observed them drawing diagrams to illustrate the information given and correctly labeling answers.

Student work grew from showing very few procedural steps and stating an unlabeled answer to diagramming the problem and using several procedural steps to show how the student arrived at his or her answer. This growth illustrates a major development of mathematical communication by the student. To teach our students to be mathematicians, we must first teach them how to communicate like mathematicians; reading mathematics is where it all starts. Pre-reading mathematical concepts partnered with required note-taking are two tools an educator can implement in the classroom to get the communication started. Adams (2003) agrees, “When we pass up opportunities to focus children’s attention on mathematics as a language and not just as something we do, children may miss the underlying concepts of mathematics that would enhance and reinforce their understanding” (p. 787).

### **Conclusions**

This research study found that when students are given the opportunity to experience mathematics from several different resources, student success and participation increases. Students need to be led to the resources and must have the desired behavior modeled for them. Pre-reading materials and requiring students to take notes

prior to class discussions mark the beginning stages of developing independent learners. Some students will find these tasks painful at first but as time progresses these experiences will empower them with the skills to become better mathematics students.

At one point during this study, I had an eighth grade student approach me prior to class and say “I really like knowing what we are learning about before I come to class. I can follow along better.” Prior to this project I was often reminding this particular student to pay attention to what we were doing on the board several times during class discussions. At the time of this student’s comment, I had made a note in my journal that this same student had become more involved in class discussions and had put more effort toward homework assignments. Providing students with experiences using the mathematical language will build mathematical self-esteem and enforce independence.

“Instruction that helps learners view mathematics as a tool for solving problems, participating in recreation and other pleasurable activities, and making sense of the world as the learner sees it is instruction that motivates students to read mathematics” (Adams 2003, p. 794). As a teacher I have learned so much about mathematics through reading textbooks, working through example problems, and sharing ideas with my peers. I believe reading the material from the textbook is only the beginning of learning mathematics, and if students aren’t reading, they are missing a vital part of the learning experience. I want to give my students the best mathematical experience possible, and I believe it starts with reading the material and taking notes on one’s own.

### **Implications**

As a result of this study, I have gained immeasurable experience about how students learn in the mathematics classroom. The sole focus cannot be to show students how to do the mathematics, but they also need to experience it through many resources. Prior to this study my students and I were content to exist in a classroom where the teacher led the discussion and basically lectured the material to the students. Some students were successful and others believed that is just how a mathematics class was supposed to be taught.

Watching students struggle mathematically made me realize I needed to provide and require students to experience mathematics using several resources. This project provided evidence of improvement in mathematical communication, verbally during class discussions and in written form in student work; I am convinced pre-reading mathematical concepts and requiring students to take notes are a necessity in any successful mathematics classroom.

Next year I intend to incorporate pre-reading activities for each concept studied in my 8<sup>th</sup> grade classroom. Some of the readings may be textbook material and other readings may include historical background information and supplemental snippets from resources other than the textbook. Each of my students will be required to keep a composition notebook for individual and classroom note taking and for the purpose of jotting down questions to be shared. I want students to know that in order to learn mathematics they must do more than just show steps on an assignment. My students will keep a record of what they have seen, heard, read, and worked on so that they have another valuable resource to which to go back and refer. I want to try implementing a

pre-test/post-test assessment before and after each unit studied in order to show student growth.

Any time an educator adopts a new teaching and learning strategy, it takes time to implement it and patience to see it grow. As I implemented the pre-reading assignments, I was overwhelmed by the amount of time it required to plan and assign the material and then to allow the students to share what they found. Once the students and I figured out the process, classroom discussions became more direct and to the point, and students were quick to lead the way during question time. I was amazed at how a teacher-led discussion became a student-directed one.

Conferences and in-service programs organized through school districts and state and national organizations provide outstanding professional development opportunities. I intend to share what I have gained through this research project at my local ESU and at state and national conferences. My advice to anyone wanting to implement a pre-reading program is to get organized. Investigate different reading strategies and activities, choose one or two to implement, plan in detail how to incorporate the strategies and activities into the classroom and do it. Sometimes change is rough at first, but with practice, time, and patience the details will blend together, and the process will become much smoother.

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## Appendix A

### Student Interviews

1. Do you take notes in mathematics class? If so, how often do you take notes?
2. Are your notes helpful when you do your assignments?
3. Do you read through sections in your textbook? If so, what do you look at most? If not, why don't you read through your textbook?
4. How often do you reflect over new material taught in class? What do you write about?
5. What do you find to be the most helpful about this mathematics class?
6. What do you find to be the most frustrating about this mathematics class?
7. Do you like mathematics as a subject? Why or why not?
8. As you read through a mathematics assignment, do you ever get confused? What confuses you the most?
9. How do you learn new vocabulary words or symbols best?
10. What is the best way to learn how to work through a math problem that is "new" to you?
11. As you begin an assignment, do you find the directions helpful or more confusing?
12. Do you find it helpful to write out a reflection about what you have learned as you finish a quiz or a test?
13. If you could change something about the way I teach mathematics, what would it be?
14. If you were to give advice to the students coming into this class next August, what would you tell them?

## Appendix B

### Student Survey

5 = Strongly agree      4 = Agree      3 = Don't know      2 = Disagree      1 = Strongly disagree

**Circle the number that best represents your opinion.**

1. Do you read about concepts in your mathematics book before they are taught in class?  
5                      4                      3                      2                      1
2. Do you take notes about concepts before they are taught in class?  
5                      4                      3                      2                      1
3. When you read about concepts in the textbook, do you write down questions about information you don't understand?  
5                      4                      3                      2                      1
4. When you read your mathematics textbook, do you look up words and symbols you don't know?  
5                      4                      3                      2                      1
5. Do the notes you take in class help you work through your mathematics assignment?  
5                      4                      3                      2                      1
6. Given time to reflect over a new concept, does it help to write down what you know and questions you still have?  
5                      4                      3                      2                      1
7. Is the textbook easy to read?  
5                      4                      3                      2                      1
8. Do the examples shown in the textbook help you understand the process being used?  
5                      4                      3                      2                      1

**Write a quick comment to finish each of the following statements.**

9. What helps me most in mathematics class is ...
10. The hardest part of mathematics class is ...
11. We have the most fun in mathematics class when ...
12. When I don't understand a mathematics assignment I ...

## Appendix C

### Student Journal Prompts

1. As you pre-read the material for class today, what did you find easy to understand?
2. As you pre-read the material for class today, what did you find confusing or difficult to understand?
3. When you pre-read material for class do you feel better prepared for the class discussion? Why or why not?
4. How could the teacher help you to better understand your pre-reading assignment?

## Appendix D

### Teacher Journal Prompts

*What impact does required pre-reading of textbook material have on students' mathematical understanding?*

- Did students pre-read the material? List evidence.
- During class discussion, did students ask questions about the reading?
- Was this pre-reading assignment worthwhile? Should the section be pre-read next year? Does the teacher need to give any guidance prior to reading?

*What effect can note taking have on students' mathematical understanding?*

- Do students take notes? When, during class discussion or at end of discussion?
- During class discussion, do students participate while taking notes?
- Do students use proper mathematical language in their notes?