7-2007

Here is the Plan: So What is the Question?

Dot Snesrud
Osceola, NE

Here is the Plan:
So What is the Question?

Dot Snesrud
Osceola, NE

Math in the Middle Institute Partnership
Action Research Project Report

in partial fulfillment of the MA Degree
Department of Teaching, Learning, and Teacher Education
University of Nebraska-Lincoln
July 2007

Here is the Plan:
So What is the Question?

Abstract

In this action research study of my classroom of 5th grade mathematics students, I investigated their understanding of the mathematical operations by having them write problems to match given equations. I discovered that writing a story to match an equation does provide insight into a student's understanding of mathematical concepts, however, reading comprehension is a factor in the understanding. Readers who struggle with comprehension do struggle with understanding and writing math story problems. The discussion that follows the writing of a math story problem and the solving of the written problems helps to strengthen the students' mathematical abilities as well as their communication skills and confidence levels. Through my study, students learned that it was alright to make mistakes because the learning from those mistakes is what is important. As a result of this research, I plan to continue to have students write stories to match given equations as a source of information about student understanding. I will continue to give opportunities to revisit those written problems as a tool to increase students' comprehension and communication skills, as well as their confidence.

Teachers often struggle with students' understanding of mathematical concepts. We often see students able to solve equations, however, not able to apply them in real world situations. I am frequently frustrated with students who seemingly can do the computation but do not have an understanding about why they are doing a particular computation to solve a particular situation. I wondered why students were able to do the computation but not relate those computations to the world around them. How can I find out what students understand? Norm referenced testing scores seemed to indicate my students were quite competent but their actual work proved differently.

My classroom was a small group of fifteen students this year. I had one student who was working at below a third grade level in math and reading and attended class for both math and reading with other students at her level. Another student also attended the reading class at below third grade level but remained in my classroom for math, working on below grade level skills in math. The students who were in my room for math worked well with each other no matter how I grouped them. Whenever the student who usually left our classroom for math class was in the room during math, the students all helped her to feel like she was a part of the group. They tried to explain what they were doing and often gave that student a job that the student was able to do during the activity in spite of not being able to do the actual mathematics – e.g., recording answers, getting materials, manipulating materials as they recorded results.

According to the Iowa Test of Basic Skills (ITBS) scores for math computation, the students were exceptional (See Appendix A). Nine of the fourteen students in my math class who took the test as fourth graders had an 85% or better on the math computation section of the testing. Seven students had a 95% or better. I was excited about the possibilities with a class that had such high scores. In class, their work did not demonstrate the same ability their ITBS scores

showed. Their computation was inaccurate. The students generally were not very communicative about what they did to arrive at an answer. They could not explain how they arrived at their answers or why they chose the operation they used to solve a problem. However, the goal of my research was to increase their communication and my understanding of what they know and comprehend. As a means of increasing their communication about what they did and did not understand, I gave them a variety of strategies to share their thinking while solving problems, including having students write stories to explain a given equation. In writing these stories, I hoped to acquire a better idea about students' understanding of the mathematical concept involved in the equation.

I tend to introduce mathematical concepts in relation to my world. I have been complimented by administrators and parents for presenting this way. For instance, if we're working with averages I might say something like, "If am asked by a teacher from a different area 'About how many students in each classroom are there in your school building?' I would think: 'There are 15 in my class which is the smallest in the building. I know Kindergarten has 23 students and it's the largest so the average is (23 +15) divided by 2 to get about 19 students, which is an estimate. What could we do to figure the actual average?" I believe this is why I often get frustrated by students who are not able to do the same. I like to present many hands on activities to help students see patterns and understand concepts better. I have felt frustrated because students see the use of manipulatives and hands on activities as 'games' and not really the work of doing mathematics. They often love to do activities but balk when are asked to evaluate or use an activity to help them 'do mathematics'.

With state standards taking so much time and energy of students and teachers, I feel students have been asked to focus on the answer but not held as accountable for the mathematics

behind the answer. In Klum's (1994) book, *Mathematics Assessment What Works in the Classroom*, he states "One of the real challenges in teaching mathematics is to find a balance between conceptual understanding and procedural skills" (p. 18). I think we all tend to be focusing on whether students can do the computation and have been neglecting the question of whether they understand the concept. While focusing in this way we have also tended to imply to students that there is one way to solve a problem. I have always tried to give students the chance to see multiple ways to solve equations. I have had students share their solutions especially when they have solved something using a different method than most.

Although I know that reading and writing has been a focus for our school, I found that students were reluctant to write about mathematics. Could it be because they did not understand the mathematics in a confident way? Was it because they did not know how to write a story? Scores indicate the students were very competent. The State Standard Writing Scores indicate that 100% of the class had met or exceeded the standard (See Appendix B). I realize that the writing required for the standard was fiction about a topic not related to mathematics. The writing of a story to match an equation is more specific and limiting, however, should require the same writing skills that the state standard expected such as giving a setting, clarity of an idea, staying on the topic, organization, grammar, and spelling. Showing proficiency in writing means a student has the capacity to make ideas known to others in a clear concise manner. The writing of the stories should give me insight into my students' understanding of the mathematical concept behind the equation.

I have always observed that those students who struggle with reading comprehension, struggle with understanding story problems as presented in mathematics. Would this go the other way? Would those who struggle with comprehension also struggle with writing stories that

match equations? The writing scores indicate that all students, even those who struggle with comprehension, are competent in writing (See Appendix B). The students know the equation already so will reading comprehension be a factor in their ability to create a story problem to match the equation? Although their writing scores are high, I think there will be a connection between those unable to write stories and those who struggle with comprehension in reading. For example, I have two resource students as well as two students identified as Speech Language Impaired. I expected them to have trouble communicating their explanations of their work and writing the problem to match the equation.

As I work through this research project, will I be able to improve this understanding of concepts? I am hoping that as students work through the writing and then revisit the problems written by students as problem solvers they will gain new insight and they will be able to share their understanding of the mathematics they used to solve the problems and make connections between past knowledge and present learning.

Problem Statement

How can a teacher know if students really understand a concept when they demonstrate they can do the computation? The whole issue of state standards has focused on student understanding. But is that understanding of procedural skills or understanding of the mathematical concepts underlying the procedural skills? Throughout my years of teaching I have found that students can do the computation but do not always demonstrate understanding of why they did a particular operation.

Just testing procedural skills does not ensure understanding of the mathematical concepts being taught. Alternative assessments such as open ended problems where students are expected to show how they use computation and describe the strategies used to arrive at an answer give a

better picture of the students' understanding of a concept. Teachers need to find ways to assess this deeper understanding and use that knowledge to stretch students' mathematical abilities. Relying on only procedural skills testing is cheating students. The students need to be aware of the mathematics involved in what they are doing. The procedural skills can be taught without the understanding of the concepts but then the students are limited in what they can do with those skills. The higher level mathematics are dependent on the conceptual understanding behind many of those procedural skills taught at this level.

At the beginning of the year, I felt this group of students was behind any group I had ever had, although my expectations based on last year's ITBS scores showed they should have been an outstanding group (See Appendix A). Many of these students did not know their math facts, which slowed them down on procedural tasks. They made lots of mistakes in their computing and when asked about their mistakes, many could not see their own mistakes. They had trouble evaluating their work or seeing that their answer was not a reasonable one. It is a group of students full of surprises. There is a wide range of paces at which students work, so finding a balance so as not to frustrate the worker who is focused and wants to understand yet keep the fast worker who is not as motivated to understand the why can be difficult and challenging.

Literature Review

While investigating what others had found concerning evaluating students' conceptual understanding, I found these related themes occurring in the literature: assessment, writing for understanding, metacognition and reasoning, posing problems, and teacher questioning. Generally the literature on conceptual understanding covered mostly assessment and writing across the curriculum. Only the Linn (2004) article came close to my proposal of writing a story problem to match an equation, and it dealt with teachers designing problems rather than the

student designed problems, which are the focus of my study. The evaluating of student conceptual understanding requires an understanding of writing, assessment, reasoning skills, and questioning skills as one considers the implications of the proposed study. Each is a consideration in the study of student conceptual understanding as they write problems to match equations.

Assessment

Klum (1994), in his book *Mathematics Assessment – What Works in the Classroom*, provides math teachers with practical resources for planning and implementing alternative assessments in the classroom. The goals for mathematical assessment should be to provide insights about the students and their abilities and understanding of the concepts.

> The primary purposes of assessment in the classroom are as follows: improvement of instruction and learning; evaluation of student achievement and progress; feedback for the students, providing information to aid them in seeing inappropriate strategies, thinking, or habits; communication of standards and expectations; and improvement of attitudes toward mathematics (Klum, 1994, p. 4).

The first two of these goals point more toward traditional tests and quizzes. The other three goals are more obvious related to alternative assessments. They provide more information for the teacher and student in details of their learning. Traditional testing tends to assess procedural skills but does not always give indication as to students' real understanding of concepts. "One of the real challenges in teaching mathematics is to find a balance between conceptual understanding and procedural skills" (Klum, 1994, p.18). With modern technology there are lots of ways for students to find an answer. Traditional testing, if technology is allowed, will not test anything but students' knowledge of manipulating electronics. "Direct assessment of strategic knowledge also requires specific approaches. It is not sufficient to provide problems and determine whether the answer is correct. The processes and strategies themselves must be

the objects of assessment" (Klum, 1994, p. 26). Therefore showing work and adding explanations to their solutions enhances a teacher's assessment of students' mastery of concepts.

Grades are not the only way for students to gain a feel for their accomplishments. Students need to be able to evaluate their own learning about the concepts also.

> Students can learn mathematics best when they are closely involved with teachers in the process of making judgments about their own learning and in taking responsibility for the achievement outcomes. Rather than blaming a test for poor learning or achievement, this approach helps the teacher and students to work together, first to define criteria for success, then to cooperate in achievement (Klum, 1994, p. 34).

Through the writing and sharing of problems, the students will have an avenue to evaluate what they know, how they know it, and what they need to know in order to make mathematics all sensible.

Writing for Understanding

Story problems in math have the reputation for being difficult. Koedinger and Nathan (2004) explore how differences in problem representations change both the performance and underlying cognitive processes of beginning algebra students engaged in quantitative reasoning. Understanding story problems has two phases – the comprehension and solutions phases (Koedinger & Nathan). The comprehension phase includes time to process the text and then create internal representation and quantitative relationships. Understanding the inconsistency of language, such as when a problem says "more than" but subtraction is needed to solve it, as well as understanding the mathematical vocabulary in order to make sense of what the problem is asking are both necessary for student success. A lot of mathematics is abstraction. College students in a math methods course could not adequately explain "what three is" individually, however, collectively they could because of the commonality of the examples they brought showed three but could not show the link between them (Marshall, 2006).

Many textbooks claim to use “real world problems” to support the particular concept being taught at the moment. Everything about these textbook problems is usually straightforward and it is usually fairly obvious as to what operation or algorithm the student should use to solve the problem. Life is not this neat and tidy. Real world problems get messy and so understanding of the reasonableness of an answer is also an important part of the learning. When the textbook story problems only deal with the concept in the particular chapter, there is not much thinking going on and ‘understanding’ can be limited to remembering what chapter the class is doing (Rice, 2004). Writing an explanation to show their comprehension and solution process is a way to be aware of students’ understanding (Rice). Rice wrote an action research paper about how using writing to teach math affects students’ math understanding.

Writing those explanations are also a way to understand students’ thinking through the problem. Writing is valuable because it forces student to become actively involved in the learning (Rice, 2004). Journals can be an informal way to gather information about students’ thinking processes (Lin, 2004). Writing and talking about their world and the problems they face within that world is a way to make their mathematical thinking visible. An advantage to using writing is it is hard for a student to hide behind the correct answer when they need to explain how they came to that answer (Rice).

Teaching the procedure for writing a journal helps students understand why journals are important to the teacher as well as to themselves. Informing the students that some parts of their journals will be messy but other parts will be in sentence form to explain their reasoning helps the students write everything they do in their journals (Lampert, 2001). Some students may draw diagrams, t-charts, etc. in order to explain their thinking. Their best work is encouraged in spite of the ‘messiness’ of their solution (Rice, 2004). This knowledge about journaling and reflecting

will help students better communicate their learning, explain their solutions, and inquire about what they don't yet understand.

Metacognition and Reasoning

'Meta' is a prefix meaning "along with," "beyond," "among," and "behind". Cognition means the act or process of knowing; perception; or the product of such a process; something thus known, perceived. Therefore metacognition has come to refer to the knowledge one has of one's own cognitive process and abilities. Metacognition is thinking about one's thinking. Metacognitive awareness is needed in classrooms because students need to be aware of how they use the skills they have (Rice, 2004) and evaluate what they haven't mastered yet. Students must learn how to use the skills they have in order for those skills to be useful.

In mathematics, Pugalee (2001) outlined these metacognitive behaviors associated with problem solving or approaching authentic tasks:

> **1. Orientation**. *Comprehending* the problem and *planning* the solution strategy. Asking oneself, "What is the problem all about"?
>
> **2. Organization**. Constructing *connections* between previous and new knowledge. Asking oneself, "What are the similarities/differences between the problem at hand and the problems you have solved in the past? and why?"
>
> **3. Execution**. Using *strategies* appropriate for solving the problem and *monitoring* the solution process. Asking oneself, "What are the strategies/tactics/principles appropriate for solving the problem and why?"
>
> **4. Verification**. *Reflecting* on the processes and the solution. Asking oneself, "What did I do wrong here?" or "Does the solution make sense?" (p. 237)

In my research, students will attempt to comprehend an equation then writing a problem to match. They will need to organize their ideas, construct connections to their world, and use strategies such as word choice, choosing important information and how much information to include. They will have to evaluate their final product to decide if their written problem does match the equation.

In a study by Lin (2004), solutions done for a particular problem were displayed, and other students were asked to come up with a problem to explain it. Those problems done incorrectly were not aligned with the original problems. The students solving incorrectly were able to see their mistakes better and think about what they need to do differently.

The brain will more than likely forget the things that it did not understand (Marshall, 2006). This may explain why research done by Koedinger and Nathan (2004) shows that money problems have a higher rate of successfully being solved. Most students have experience with money outside of school. That experience helps makes the concept easier to comprehend and remember.

There is much research on reading comprehension abilities having a direct tie to comprehending word problems in mathematics class. Research on reading has identified several effective cognitive strategies for students to use in reading comprehension. Hyde (2006) identified the following strategies: making connections, asking questions, visualizing, inferring and predicting, determining importance, synthesizing, and metacognitive monitoring. He reiterates that the NCTM Standards names five processes in which students need to be engaged: problem solving, connections, reasoning and proof, communications, and representations. He then connects these reading strategies with the mathematics processes.

Posing Problems and Teacher Questioning

When posing problems teachers must construct them carefully in order to give the students opportunities to do higher level thinking. There are many things to take into consideration when composing the problems. They must be open-ended enough to allow some 'messiness' to happen. That messiness allows for students to make connections between their learning. It can be an informal way of assessing students' thinking (Lin, 2004).

Koedinger and Nathan (2004) represent six problem categories representing two difficulty factors: representation and the unknown. Story problems can be easier when stories evoke more effective strategies than the equations. Students generally did better with story problems where the result was unknown rather than the start number whether the problem was using whole numbers or decimals. They generally did better word equations and story problems had basically the same success rate over equations in problems with whole numbers but when working with decimals, the story problems had the highest success rate. Students' success will be determined in part by their experience with verbal and symbolic representations.

Story Problem	Word equation	Symbolic equation
Result unknown: When Ted got home from his waiter job, he took the $81.90 he earned that day and subtracted the $66.00 he received in tips. Then he divided the remaining money by the 6 hour he worked and found his hourly wage. How much does Ted make per hour?	Starting with 81.9. If I subtract 66 and then divide by 6, I get a number. What is it?	Solve for x: (81.9-66)/6=x
Start unknown: When Ted got home from his waiter job, he multiplied his hourly wage by the 6 hours he worked that day. Then he added the $66 he made in tips and found that he had earned $81.90. How much does Ted make an hour?	Starting with some number, If I multiply by 6, then add 66, I get 81.9. What number did I start with?	Solve for *K*: *K* x 6 + 66 = 81.90

Although there is not much research about the student writing of word problems to match a given equation, the research provided food for thought about the types of problems to pose and why one would work better than another. It supported the idea that writing is a way for students to think about their thinking and also a window for the teacher to see their thinking. The idea from Lin (2004) to have students share shared work and see each others' correct and incorrect answers and strategies will be a way to 'learn from our mistakes.' Klum (1994) supports the writing of stories to match equations as a way to investigate the understanding of concepts. No study has looked at students doing the writing for the purposes of evaluating an understanding of the math concepts.

Purpose Statement

My research is studying the use of a specific alternative assessment to determine students' understanding of concepts. In giving equations, the students, based on their understanding of numbers and operations, will develop a story problem that matches that equation. As students develop stories, I will aim to evaluate their understanding of operations and when it is most efficient to use a particular operation.

I am seeking to be clear about what my students understand and to stretch their abilities to use different strategies to solve problems. I hope one benefit will be that students become better communicators in the mathematical process. As they learn to increase their communication, I hope my understanding of what they know and comprehend will also increase. In those students who struggle with this activity, I will have a clearer idea about what it is they are not understanding which should lead me to better helping them achieve understanding.

The ideal classroom in my mind is one where students freely share their understanding with others in the class by sharing moments of insight, asking relevant questions to help their

own understanding, and asking probing questions of their peers to help others reach similar insights. An ideal classroom also includes students evaluating their own work, and determining what they still need to learn in order to master the concept. They feel safe asking questions, taking risks when sharing their work and ideas, and are motivated to probe more deeply in their own understanding of mathematical ideas.

By conducting this research, I am hoping to find strategies to assess students' understanding of mathematical concepts by having them write story problems to match equations. I will be examining the variables of student attitudes towards mathematics, the problems written to math an equation, the students' problem solving ability, students' computation ability, and students' reading comprehension ability in seeking to answer the research questions:

- How can story problems written to match equations be used to assess student understanding of mathematical concepts?
- How do the students' attitudes towards mathematics enter into the writing of the story problems?
- How does a student's reading ability impact a student's ability to write mathematical story problems?
- What can students learn from writing story problems to match an equation?

Method

IRB letters were distributed during Parent/Teacher Conferences on February 7 and 8, 2007 (See Appendix D for a copy of the consent forms). After these were returned the next week, I began my research by collecting information about my students' attitudes about school subjects and mathematics given February 16, 2007. I created the survey after looking at several examples. I included a variety of ways to gain insight into their attitudes (See Appendix E). I had an aide assign the students an ID number for purposes of ensuring the students that they should

be honest about their responses. I analyzed the data to see where there rating of math fell (See Appendix F).

The surveys were also completed at the end of my study, April 27, 2007, in order to compare attitudes about mathematics and how they might have changed during the duration of the study. I had gathered Iowa Tests of Basic Skills (ITBS) information from my students fourth grade year at the beginning of the year so I had the scores for reading and mathematics. When scores were returned in May for the March testing of fifth grade, I collected those scores. When comparing fourth grade scores to fifth grade scores I decided to also gather third grade scores for the same parts of the ITBS testing (See Appendices C and K).

I wrote the first set of equations that I gave as a baseline for the gathering of written stories. The first equations were addition and subtraction (see Appendix G) which were given to students to write stories for on February 20, 2007. Then the next week, February 27, 2007, I assigned multiplication and division equations (see Appendix G).

I considered these my baseline equations. They were basic operations with numbers less than 100. I also developed a rubric to evaluate the stories written to match the equations. In evaluating the stories I looked for two main points: Did the story match the equation, and did the story represent an appropriate real world situation (See Appendix H)? When I assigned the equations to the students, they were instructed to write the story that is behind the equation, then solve the equation.

On March 9, 2007, students were given some of the story problems that had been written and solved in February. They worked alone on these problems. Then on March 12, 2007, we discussed their solutions for these stories. I gave the stories back for students to solve a week

after the original equations had been assigned so that it would be less likely for someone to remember the original equations.

Another set of equations were given to the students on March 23, 2007, which was the end of the week of ITBS testing for my class. I gave more difficult division problems since the base set of problems showed the area of weakness was division (See Appendix D). I was pressed for time so I randomly had half of the class do one of the problems and half the class did the other problem. With spring break and an unexpected teacher in-service, I did not get back with students to these stories until April 11, 2007. Before giving them the stories to solve, I had everyone solve the equations first just to assure me that they could do the computation. When these stories were presented to the students, they worked in pairs to come up with solutions and then we discussed the stories and the solutions. They also solved some problems the next day as well and then we discussed their solutions. This is when they remembered the equations I had them solve and students began to notice for themselves how different some of the stories were.

The final set of equations included an addition of fractions equation since we had been working on fractions for several weeks. The other equation was more complex including addition and division (See Appendix G). I had been reviewing mean, median, and mode off and on since a graphing unit. I thought students might see the concept of adding and then dividing in figuring mean embedded in the equation. These equations were given on April 19, 2007 and the stories were given to small groups to solve on April 25. I had completed the rubric on the stories but lost the class's solutions as well as my anecdotal journal in a fire that occurred as a result of a bus accident coming home from our class field trip. In reporting my findings, I have tried to paraphrase what students said and did during the work within the classroom. Some reflections are based on my memory and others are based more on a feeling in hindsight about some event.

Findings

Looking at the attitude survey results, math was placed first by 53% of students when they ranked their six core subjects in February (See Appendix F) and only 47% of the class in May (See Appendix I). The ratings questions rose overall but not by anything significant, except one individual did move his/her ratings significantly in the positive. One student rated almost all the questions very low in February and very high in May. This particular student really became excited about math this year. She was excited about solving problems and persevered until she came to a solution that seemed reasonable and with which she was satisfied. I noticed that the confidence levels for all students in regard to showing work increased a lot. The strategies and practice seemed to help boost their confidence in explaining their work. The class as a whole became much more willing to ask questions about each others' work and take the risk of sharing their solutions even if they were not absolutely sure their solutions were correct. I am pleased with the fact that the class's comfort level in asking questions rose. While I was hoping to find that students' attitudes toward mathematics influencing their performance in writing story problems, my evidence instead showed no difference in story problems based on student attitude. If I had been doing this all year, would there have been more of an impact on their attitudes?

When I began looking at the stories written by my students, I was not surprised at how well the addition and subtraction stories were written. These are operations they had been doing for years. Most of them did not hesitate to complete the task, were confident about the story topic, and had a solid problem that other students could solve. After assigning the second set of equations – the multiplication and division – I had a surprising complainer. One of my best readers and by far the best writer in the group asked me over to her desk. She asked several questions, mostly about what kind of stories they were to write. She was struggling with this and

I was confused as to why. I referred back to the addition and subtraction equations we had done the week before with which she had not blinked an eye about writing. Now, suddenly, she was almost whining about having to do these two stories. I tried my best to encourage her and assure her she had the ability to do these and then left her to think. She came up with two stories that were well done although the wording of the question for the division was a bit awkward. It made me wonder if the complaining had been her way of showing her uncertainty in a new situation and her fear of failure. Here are the problems she wrote:

> **Multiplication problem Student 13**: Hegge's flower shop is planting new flowers. There are six rows of flowers. Each row has twelve flowers. How many flowers in each row?

This problem shows she has connected the idea of multiplication with the concepts of arrays.

> **Division problem Student 13**: There is a party being held at the auditorium. There are 48 people coming. There are six tables. How many chairs will they need to fill each table?

This division problem shows her understanding of dividing into equal groups.

This same student did very well when writing the stories for the average equation. The fraction problem followed a plausible idea but again her wording was a bit awkward.

> **Fraction problem Student 13**: There was a small party. Julie bought three pizzas. She cut the pizzas into eighths, fourths, and halves. When the party was over there were ½ of a pizza, ¾ of another pizza, and 3/8 of the favorite pizza. What fraction of the pizzas was left?

I recall when students solved this story; they had questions about the wording of the problem's question. Taken literally they thought the author had already answered the question.

While looking at the attitude surveys of this student, she kept pretty much the same attitudes except for raising the importance of math and lowering her happiness about answering questions. Judging from the comment from the last question on the May attitude survey, some of her changes came from pressures about grades from home. In the survey, I asked students to complete the following statement, “One thing I wish my math teacher knew about me is.” This student responded, “I am not good with math, science, reading, social studies, and I am supposed to get my grades better before school ends!” Her grades have been exemplary all year and it appears I was taking her outside her comfort zone. I hypothesized that reading and writing ability affected a student's ability to write story problems, however my data showed that the above average students seemed to struggle as much as anyone. Was this lack of understanding, lack of confidence, or lack of experience sharing this kind of thinking?

When students tried to solve the story problems their classmates had written, I saw the value of the project. In solving the problems, students had to think about the equations. I did not return the stories to be solved immediately because I wanted them to solve for the problem written, not the equation they may remember having to create a work problem for. I typed up some of the problems, including a sample of good, bad and confusing problems. I initially read through the problems and made notes about how I interpreted them. Then I used the rubric to make a quantitative judgment about each problem. Then I tried to use samples of well written problems, problems that went awry from the original operation, and problems that would cause confusion because of the way they were written. I gave students the first set of peer written problems and had them work on their own. Then we discussed the problems and which ones with which they struggled. We compared answers to problems. Here is one example.

> "There are 12 puppies in a litter. Then they found 6 more litters with the same amount of puppies. How many puppies are there?"

This story included basically two solutions. They were the given equation of 12 * 6, but many solutions had the equation 12 * 7. Many picked up on the fact that because there were six more litters there would be seven groups of twelve puppies. They looked at the problem critically. I recall one student commenting, "But the equation she gave us was 12 * 6!" and another student responded, "Ms. Snesrud wants us to solve the problem by how they are written not how they were supposed to be written." The student making that statement pointed to this problem and showed that this was **the** equation that was given.

> "There were 12 boys. What if five groups of 12 boys joined them, how many boys would there be?"

Students with these two examples became more aware of the subtle differences in a statement. In this case, the mathematics may have been impacting the reading skills rather than my assertion of reading impacting the mathematical writing.

The next time I shared a set of student written problems, students solved the stories with a partner. The level of discussion both while solving and during the sharing of solutions was amazing. The students began asking hard questions. Some of those students who in the past were not willing to share unless called on by a teacher began to share their answers even defend answers when someone seemed challenged their solution. They were willing to take risks.

A student who has struggled throughout the year with math used the survey to provide me with some important information about her gaps in mathematical understanding. Her comment on the February survey was one I had suspected but she confirmed. I asked the students to complete the following statement, "One thing I wish my math teacher knew about me is."

This student replied, “I need more help than she thinks. I don’t understand division because I was gone last year when we learned about it.” Unfortunately, she missed a lot of days in April due to her mother’s illness and it was difficult to get her caught up when she returned the end of April. She did very well on the averaging equation, however, on the fraction problem she did not show understanding. She wrote,

> “½ of the 3/8 of an eraser was broken. ¾ inch of the 3/8 inch pencil was broken. (This 3/8 in both sentences is just used once.) How many inches in all of them?”

In studying this problem, I noticed problems with value of fractions. I wonder if she just did not understand how to word the idea she was picturing when she said “¾ inch of the 3/8 inch”? The writing in this case may be more of the problem than the mathematics. The same week she wrote this problem:

> “At the carnival in Osceola, 139 people showed up on Monday. On Tuesday, 143 people attended. Sodas were free all day. On Wednesday, 144 people came. On Thursday it rained so no one came to the carnival. On Friday, the last day, 154 came. What was the average amount of people at the fair each day people attended?”

She included some extra information and had a day with no one attending the carnival. The day that no one attended could pose problems with the solvers – does one use 4 or 5 to divide and find the average? The question specified what the average would be for the days there people attended. She was absent when we did the second set of division equations.

Some students could develop a setting for a problem and then never ask a question. This usually happened with the three students I had who were part of the resource program for

language deficiencies. They were the most likely to have a story with no question or to have a mishmash of facts that do not hold together for the question asked. Here are two examples:

> Kelsey threw the softball 139 ft. on the first throw, 143 ft. the second throw, and 154 ft. the 3rd throw, and she plans to get an average of 145 ft. but she didn't.

This child had a great start on creating an averaging problem but then got off track. Was he trying to make the problem more difficult by leaving out some information for someone to solve, or did his weakness in language ability come into play?

Here is another example of just not completing a good idea by a student.

> I had $37.98 in my purse yesterday. When I checked today I only had $25. I had to get groceries.

This student was headed in the right direction, however, never completed the problem. The lack of a question is partially because there needs to be more information, possibly, 'I had not spent any money since yesterday.' Then a question about how much was stolen would have made sense. It would not follow the original equation but would have been a plausible problem. My hypothesis that reading and writing ability affected a student's ability to write story problems is supported more readily with the speech / language impaired students.

When I was pressed for time, I had half the class write for one equation ($37.98 \div 25$) and the other half write for a different equation ($332 \div 16$). Before I handed the stories back for students to solve, I had them compute the equations to solve, since division had been a problem for many of the students. This led to something interesting. The students noticed the difference in the problems and how not all problems written led to the original equation. This was an important piece of the connection and learning process. Before this, I had left enough time so they would forget the equations so as not to influence their solutions. I found that knowing the

original equations influenced their solutions but in a way that became important to their learning about understanding where those equations come from. For some students, this became a very important ‘aha’. Unfortunately, because I lost the last set of stories in the fire, I could not follow up on this with students to evaluate this further. The last set of equations included fractions so that seemed to affect their writing some. They could set the story up but with fractions describing things but then had trouble developing a question that had a solution.

When looking at the test scores at the beginning of the year, I was excited about the high scores that indicated that this class might be a mathematically inclined group. Yet, when I began to work with them, I found understanding of particular concepts missing. Students could do the computation with ease but when asked to think critically they faltered. Many of these students did not know their math facts which slowed them down in their procedural tasks. They made lots of mistakes in their computing and when asked about their mistakes, they could not see their mistakes. They had trouble evaluating their own work or seeing that an answer was not a reasonable one. I decided to go back to third grade scores. There seemed to be a bump up in computational scores in the fourth grade scores.

With any writing activity, the discussion of how it fits together helps improve the next writing as well as understanding more about reading. I found that most students approached story problems much more critically as the semester progressed. They tended to begin with the question and work back from there to find information within the problem that they would need to answer the question. They were able to pick out unimportant information more readily.

Conclusion

The writing of stories to match given equations can help gain insight into student understanding of concepts but it is not the only thing gained. In fact, I would say it is not the

strongest thing gained. I would say that the critical thinking skills reinforced from this type of activity, especially from solving the stories that were written, is a much richer reward from this activity. The process and strategies themselves can be assessed (Klum 1994). This assessment is not just for the teacher either. The self-evaluation by students done when writing their own problems and solving others' stories has an impact on the understanding and confidence of students.

Life is not that neat and tidy. Real world problems get messy and so understanding of the reasonableness of an answer is also an important part of the learning. Many textbooks claim to use real world problems, but there is not much thinking going on and 'understanding' can be limited to remembering what chapter the class is doing (Rice, 2004). This messiness was what our discussions were full of as the students shared their ways of solving and explaining why they used the operation or numbers the way they did to come to a solution. Writing is valuable because it forces students to become actively involved in the learning (Rice, 2004). Writing and talking about their world and the problems they face within that world is a way to make their mathematical thinking visible (Whitin, 2000). During my research, students had to comprehend an equation then write a problem to match. They needed to organize their ideas, construct connections to their world, and use strategies such as word choice, choosing important information and how much information to include. They began to learn how evaluate their final product to decide if their written problem did match the equation. They gained more confidence in explaining their solutions and defending their strategies. They began making connections to their world and mathematics as well as mathematics and reading/writing skills.

As students were expected to justify and explain why they solved the stories the way they did, they became more involved in understanding their mistakes. The brain will more than likely

forget the things that it did not understand (Marshall, 2006). Students began to make connections to what they had previously done and used that to help them solve the current problem. The discussions about the solutions led to some ‘aha’ moments. I often reminded them of my mantra – It’s OK to make mistakes as long as we can learn from them.

Implications

This research study has reinforced my conviction that students need to be involved in learning and that working with partners enhances learning. Writing stories to match equations is a way to learn about what is understood by students. Those stories give insight into their mathematical thinking and comprehension abilities.

In the future, I will use the writing stories as one assessment of students’ mathematical thinking. I also will use attitude surveys. I will give a survey at the beginning of the year and the end of the year to track what impact my teaching has had on my students’ mathematical understanding and their attitudes about mathematics. I believe that starting at the beginning of the year and continuing throughout the year with students writing to match equations will be less stressful for students and for me. The whole year approach will allow for more time for discussion after each writing session and yet still accomplish everything in the curriculum. I would like to strengthen my equations and have them become more complex as the year goes on. I do not believe that doing this one semester allowed for as much growth as I might see having a whole year to use this approach with students. Both instruments helped me understand my students better and helped me better meet their needs within the classroom. When I can do the writings throughout the year rather within a two or three month time span, it will ease the time pressure I felt while doing this research and allow me to spend time with a particular concept at a more opportune time.

Test scores give one kind of information, while this assessment taps into students' world and how these mathematical concepts relate to students on their level. Sometimes I use examples of concepts within my world but that is not always a world my students can relate to yet. By having the students write problems to match an equation they are given an opportunity to make sense of their world mathematically. The discussions about written problems and sharing solutions allow students to deepen this sense making as well as the understanding of concepts. It gives them a freedom of exploring and questioning that broadens them as learners.

I would strongly recommend this approach to other teachers as one tool of assessment. They would gain insight into their students' thinking and understanding. My advice to them would be to start small and use the beginning equations as a tool for the teaching of the process both of writing and discussions. Then as teachers feel comfortable add to their repertoire of equations to match their equations. Teachers will reap the benefits by having a clearer picture of their students' conceptual understanding, but, more importantly, so will their students. Students will increase their confidence not only in math concepts but also in communicating and defending ideas, strategies and solutions.

References

Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher-education. *The Elementary School Journal, 90*(4), 449-466.

Ball, D. (1993). With an eye on the mathematical horizon: dilemmas of teaching elementary school mathematics. *The Elementary School Journal, 93*(4), 373-397.

Chazan, D. & Ball, D. L. (1999). Beyond being told not to tell. *For the Learning of Mathematics*, 2-10.

Craig, J. (2005). *Assessing the relationship between questioning and understanding to improve learning and thinking (QUILT) and student achievement in mathematics: a Pilot Study*. Charleston, WV: EDVANTIA.

Goularte, R. (2003). *Giant story problems: reading comprehension through math problem solving.* (Guides - Classroom - Teacher No. 052). Urbane, IL: Marco Polo Education Foundation; National Council of Teachers of English.

Hyde, A. (2006). *Comprehending math: Adapting reading strategies to teach mathematics, K-6*. Portsmouth, NH: Heineman.

Kenney, J. M., Hancewicz, E., Heuer, L., Metsisto, D., & Tuttle, C.L. (2005). *Literacy strategies for improving mathematics instruction.* Alexandria, VA: Association for Supervision and Curriculum Development.

Klum, G. (1994). *Mathematics assessment - what works in the classroom*? San Francisco, CA: Jossey-Bass Publishers.

Koedinger, K. R. & Nathan, M. J. (2004). The real story behind story problems: Effects of representations in quantitative reasoning. *The Journal of Learning Sciences, 13*(2), 129-164.

Kramarski, B., Mevarech, Z.R., & Arami, M. (2002). The effects of metacognitive instruction on solving mathematical authentic tasks. *Educational Studies in Mathematics, 49* (2), 225-250.

Lampert, M. (2001). *Teaching problems and the problems of teaching*. New Haven, CT: Yale University Press.

Lin, P. J. (2004). Supporting teachers on designing problem-posing tasks as a tool of assessment to understand students' mathematical learning. *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematical Education, 3*(2004), 257-264.

Marshall, J. (2006, January). Math wars 2: It's the teaching, stupid! *Phi Delta Kappan*, 356-363.

Pugalee, D.K. (2001). Writing, mathematics, and metacognition. *School Science and Mathematics, 101* (5), 236-245.

Rice, C. (2004). How does writing to teach math affect student math understanding, *an action research paper*. George Fox University, Newburg, OR: Google Scholar Search. Academic data file Retrieved November 1, 2006, from Google, Scholar: http://academic.georgefox.edu/~kcarr/mat/docs/studentwork/Action%20Research.doc

Roh, K. H. (2003). *Problem-based learning in mathematics*. Columbus, OH: ERIC Clearinghouse for Science and Environmental Education. (ERIC Document Reproduction Service No. ED4827525).

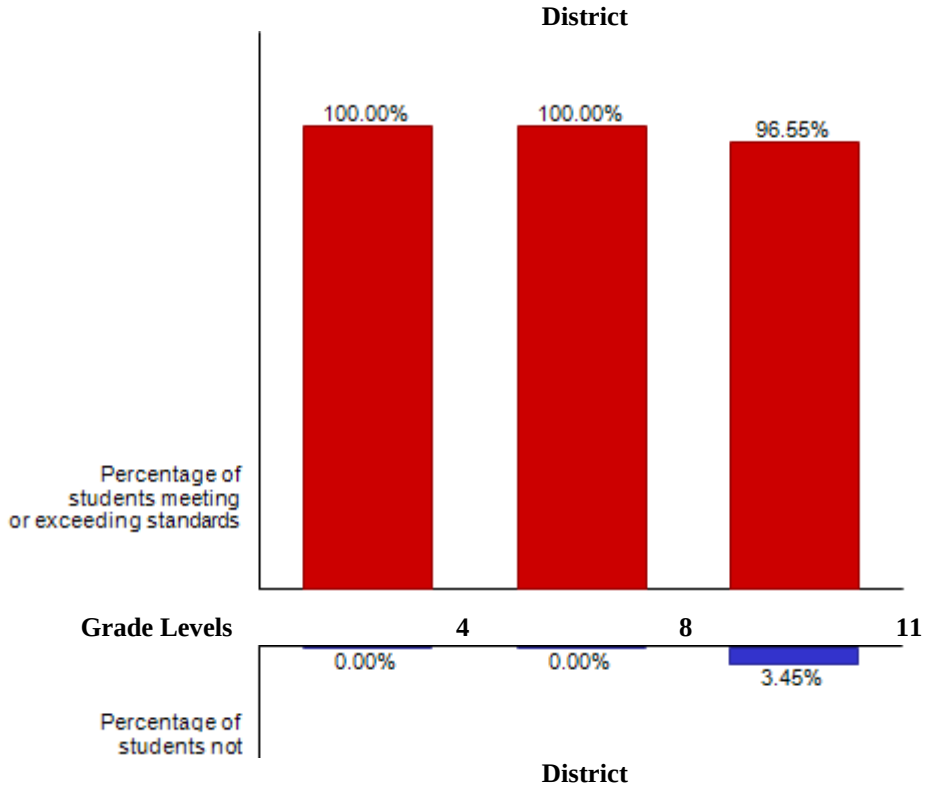
Appendix A

Iowa Test of Basic Skills
Fourth Grade Percentiles

Fourth Grade	Reading Comprehension	Reading Total	Math Computation	Math Problem Solving	Math Total
Student 1					
Student 2	74	90	99	50	60
Student 3	93	99	79	38	58
Student 4	42	84	99	62	58
Student 5	57	72	75	72	77
Student 6	26	70	88	67	70
Student 7	61	84	98	87	70
Student 8	91	99	88	87	86
Student 9	57	89	99	78	86
Student 10	70	93	99	97	99
Student 11	79	95	96	83	84
Student 12		19	52	19	85
Student 13	79	95	99	67	65
Student 14	42	72	50	57	68
Student 15	35	50	99	57	46

Appendix B
2005 State Report - Writing

Statewide Writing Assessment All Students
2005 - 2006 The Statewide Writing Assessment results show the percentage of students who met or exceeded the state writing standards in 2005 - 2006.



Student Performance

Grade Levels	Students Not Meeting Standards	Students Meeting or Exceeding Standards
4	0.00%	100.00%
8	0.00%	100.00%
11	3.45%	96.55%

Assessment of State Reading Standards
All Students in Grade 4
2005 - 2006

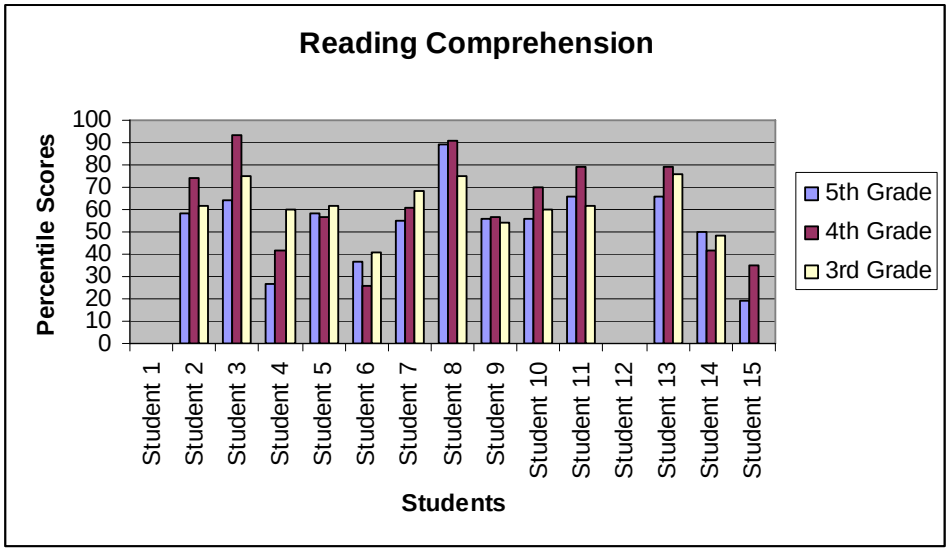
Performance on 4th Grade State Standards

Standard Number	Standard: *By the end of the 4th grade, students will ...*	Students Meeting or Exceeding Standards		Students Assessed
		State	District	District
4.1.1	Demonstrate the use of multiple strategies in reading unfamiliar words and phrases.	88.03%	100.00%	100.00%
4.1.2	Demonstrate the use of multiple strategies to increase their vocabulary.	89.56%	64.71%	100.00%
4.1.3	Identify the main idea and supporting details in what they have read.	90.26%	100.00%	100.00%
4.1.4	Identify the resource appropriate for a specific purpose, and use the resource to locate information.	91.21%	76.47%	100.00%
4.1.5	Identify and use characteristics to classify different types of text.	89.40%	100.00%	100.00%
4.1.6	Identify and apply knowledge of the structure, elements, and literary techniques to analyze fiction.	90.64%	100.00%	100.00%
4.1.7	Identify and apply knowledge of the text structure and organizational elements to analyze nonfiction or informational text.	90.03%	100.00%	100.00%
4.1.8	Identify similarities and differences between two fourth grade level reading selections.	88.68%	100.00%	100.00%
4.3.1	Participate in group discussions by asking questions and contributing information and ideas.	89.94%	100.00%	100.00%
4.3.2	Deliver organized oral presentations using complete sentences, clear enunciation, adequate volume, and eye contact.	91.42%	94.12%	100.00%
4.4.1	Identify information gained and complete tasks through listening.	91.73%	100.00%	100.00%
Overall Averages		**88.28%**	**94.12%**	100.00%

Appendix C

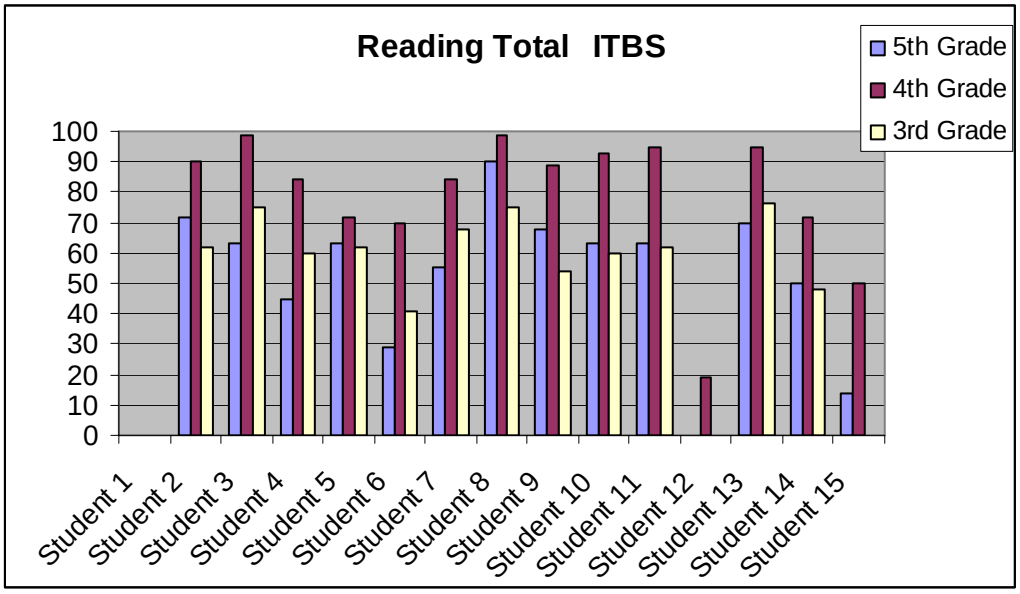
Reading Comprehension ITBS

Reading Comprehension	5th Grade	4th Grade	3rd Grade
Student 1			
Student 2	58	74	62
Student 3	64	93	75
Student 4	27	42	60
Student 5	58	57	62
Student 6	37	26	41
Student 7	55	61	68
Student 8	89	91	75
Student 9	56	57	54
Student 10	56	70	60
Student 11	66	79	62
Student 12			
Student 13	66	79	76
Student 14	50	42	48
Student 15	19	35	



Reading Total ITBS

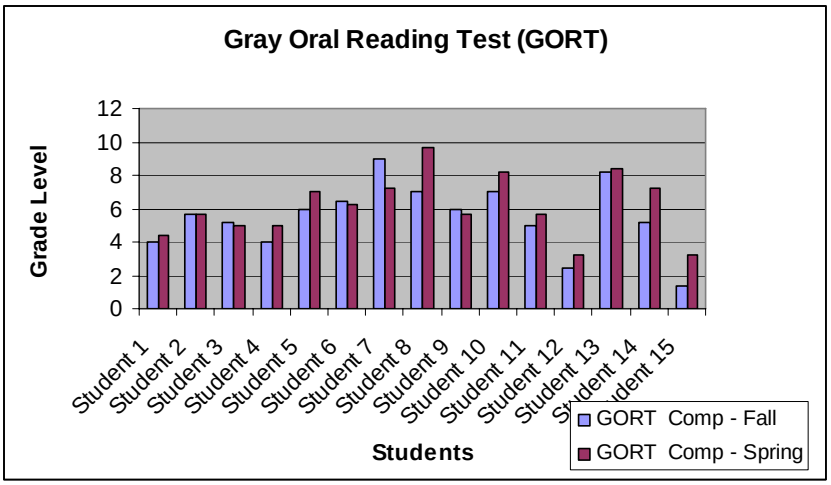
Reading Total	5th Grade	4th Grade	3rd Grade
Student 1			
Student 2	72	90	62
Student 3	63	99	75
Student 4	45	84	60
Student 5	63	72	62
Student 6	29	70	41
Student 7	55	84	68
Student 8	90	99	75
Student 9	68	89	54
Student 10	63	93	60
Student 11	63	95	62
Student 12		19	
Student 13	70	95	76
Student 14	50	72	48
Student 15	14	50	

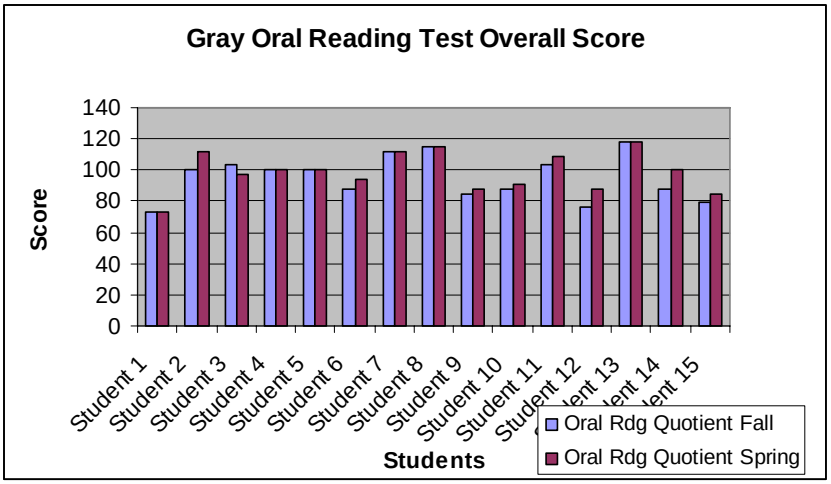


Gray Oral Reading Test
Fifth Grade
Fall 2006 and Spring 2007

GORT

Name	Comp - Fall	Comp - Spring	Oral Rdg Quotient Fall	Oral Rdg Quotient Spring
Student 1	4	4.4	73	73
Student 2	5.7	5.7	100	112
Student 3	5.2	5	103	97
Student 4	4	5	100	100
Student 5	6	7	100	100
Student 6	6.4	6.2	88	94
Student 7	9	7.2	112	112
Student 8	7	9.7	115	115
Student 9	6	5.7	85	88
Student 10	7	8.2	88	91
Student 11	5	5.7	103	109
Student 12	2.4	3.2	76	88
Student 13	8.2	8.4	118	118
Student 14	5.2	7.2	88	100
Student 15	1.4	3.2	79	85





Appendix D

IRB

Dear Parent,

I am participating in a unique program called The Math in the Middle Institute Partnership. Through this exciting opportunity, I will be earning a master's degree through the University of Nebraska-Lincoln in August of this year. One requirement of the master's degree is that I conduct a research project as part of my master's thesis. My research project will involve me studying my own teaching practice in your student's math class, and trying to increase student achievement in mathematics.

I will be studying my own teaching practice in your student's math class. Everything I will do in class will be part of normal teaching practices for the benefit of student learning. My research project will not get in the way of me teaching the students what they need to know for the Nebraska State Standards in Mathematics for fifth grade. My goals in teaching your student have not changed, and your student will still be doing regular fifth grade mathematics activities in class.

During class, we will be writing story problems for a specific equation to help the students and me better understand their understanding of mathematical concepts. On some days, I will be asking your student to work in cooperative groups. Additionally, I will interview a few students individually, during a noon recess, to ask them about their attitudes about mathematics and how they think their understanding of concepts has changed. I will audio-tape interviews and video tape of class discussions in order to help me take notes; no one but me will hear the tape. In late January and early May, I will be asking all students to fill out a short (5 minutes) survey about attitudes about mathematics. I will be keeping some copies of student work throughout the semester in order to help me see student growth in math class. I will also be looking at student achievement data on the ITBS standardized test given by our school. I will not see individual student names with scores, but will be looking at averages and student growth.

Attached is an official permission slip from the University of Nebraska-Lincoln, giving your student permission to participate in my research. While all students will be participating in all in-class activities, giving your permission means that I will include your student's data in my project, and that your student may be interviewed. Choosing to participate or not to participate in the research will not affect your child's grade or standing in math class in any way. I will not know which students are participating in the research until the end of the school year.

Please contact me at school by phone, 747-2091, or email dsnesru@esu7.org ; if you have any questions about this, and I will gladly explain my project to you. Thank you.

Sincerely,

Dot Snesrud

Appendix E

Attitude Survey **Student ID _____**

Rate the following subjects from favorite to least favorite: English, math, reading, science, social studies, spelling.

A.(favorite) 1. _____
2. _____
3. _____
4. _____
5. _____
(least favorite) 6. _____

B. Please give your honest response to each statement, 1 being low and 5 being high.

I like math.	1 2 3 4 5
I am good at math.	1 2 3 4 5
Math skills are important for other skills.	1 2 3 4 5
I am able to show the work required to solve math problems.	1 2 3 4 5
I like to answer questions asked in math.	1 2 3 4 5
I feel comfortable asking questions in math if I don't understand a concept.	1 2 3 4 5

C. Complete the following statements.

When I hear the word math, I immediately feel _____.

My favorite concept in math is _____ because

One thing I wish my math teacher knew about me is:

Appendix F

Attitude Survey results February 2007

Results of survey - Student ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Math	1	3	1	1	1	1	1	5	5	1	6	3	6	1	4		
Reading	5	6	2	4	5	2	6	3	4	5	1	6	4	5	2		
Science	3	2	3	6	3	6	4	1	1	2	4	4	5	3	6		
English	6	4	4	3	6	4	3	6	6	0	3	2	2	2	3		
Social Studies	4	5	5	5	4	3	5	2	2	3	5	5	3	4	1		
Spelling	2	1	6	2	2	6	2	4	3	4	2	1	1	6	5		
																	average
I like math	5	4	5	5	4	5	1	3	2	5	1	3	2	4	3		3.466667
I am good at math	4	5	4	4	4	3	2	3	3	4	1	3	3	4	4		3.4
Math skills are important for other skills	3	5	5	5	3	4	3	5	4	5	2	5	3	5	4		4.066667
I am able to show the work required to solve math problems	5	5	5	4	4	3	2	3	2	3	1	2	3	3	3		3.2
I like to answer questions asked in math	4	5	5	5	4	4	1	3	3	5	2	2	4	3	4		3.6
I feel comfortable asking questions in math if I don't understand a concept.	5	5	4	5	3	5	1	4	5	3	2	5	4	4	5		4
Occurrence of Rating	**1**	**2**	**3**	**4**	**5**	**6**			%1st	%2nd	%3rd	%4th	%5th	%6th			
Math	8	0	2	1	2	2			53	0	13	6	13	13			
Reading	1	3	1	3	4	3			6	20	6	20	26	20			
Science	2	2	4	3	1	3			13	13	26	20	6	20			
English	0	3	4	3	0	4			0	20	26	20	0	26			
Social Studies	1	2	3	3	6	0			6	13	20	20	40	0			
Spelling	3	5	1	2	1	3			20	33	6	13	6	20			

Appendix G

Equations assigned:

February 20	$75+20=n$ $75-48=n$
February 27	$12*6=n$ $48\div 6=n$
March 9, 12	solutions
March 23	$37.98\div 25$ $332\div 16$
April 11	solutions
April 19	$\frac{1}{2}+\frac{3}{4}+\frac{3}{8}$ $(139+143+144+154)\div 4$
April 25	solutions

Appendix H

Rubric for written problem from equation:
3 – high, 1 - low

	3	2	1
Problem matches equation	Problem matches equation and uses appropriate vocabulary for the equation.	Problem matches equation and uses some appropriate vocabulary for the equation.	Problem does not match equation.
Problem is an appropriate real-world situation	Problem uses an appropriate and plausible, real-world situation.	Problem uses an inappropriate but plausible, real-world situation. Or Problem uses an appropriate but not plausible, real-world situation.	Problem does not use an appropriate and plausible, real-world situation.

Appendix I

Attitude Survey results May 2007

esults of survey - Student ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
th	1	6	3	1	1	1	1	5	5	1	6	6	6	1	3		
ading	5	5	5	4	3	4	6	4	3	6	1	2	4	3	5		
ence	2	3	2	6	5	6	4	1	2	2	5	5	5	5	6		
glish	4	4	4	3	4	2	3	6	1	4	3	3	2	4	4		
cial Studies	3	2	6	5	6	5	5	2	6	5	4	4	3	2	1		
elling	6	1	1	2	2	3	2	3	4	3	2	1	1	6	2		
																	average
e math	5	1	4	5	4	5	5	3	2	5	1	2	3	5	3		3.533333
n good at math	5	2	3	5	4	3	5	3	3	5	2	2	2	4	2		3.333333
th skills are important other skills	4	5	5	5	4	5	5	5	5	4	3	5	4	5	4		4.533333
n able to show the k required to solve th problems	5	5	5	5	4	4	4	4	3	3	2	3	3	4	5		3.933333
e to answer stions asked in math	5	3	5	4	3	3	5	3	3	4	1	2	2	5	4		3.466667
el comfortable asking stions in math if I 't understand a cept.	5	3	3	5	4	5	4	5	4	4	3	4	4	5	5		4.2
currence of Rating	**1**	**2**	**3**	**4**	**5**	**6**			%1st	%2nd	%3rd	%4th	%5th	%6th			
th	7	0	2	0	2	4			47	0	13	0	13	27			
ading	1	4	1	1	5	2			7	27	7	7	33	13			
ence	1	3	2	2	4	4			7	20	13	13	27	27			
glish	1	2	4	7	0	1			7	13	27	47	0	7			
cial Studies	1	1	3	4	4	2			7	7	20	27	27	13			
elling	4	5	3	1	0	2			27	33	20	7	0	13			

Appendix J
Story writing rubric scores

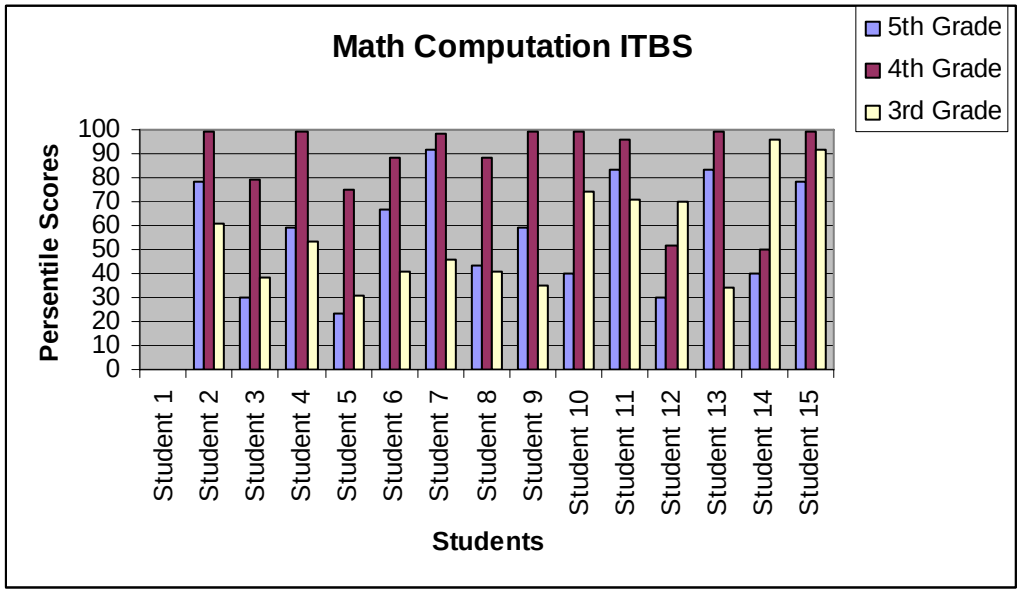
	3	2	1
Problem matches equation	Problem matches equation and uses appropriate vocabulary for the equation.	Problem matches equation and uses some appropriate vocabulary for the equation.	Problem does not match equation.
Problem is an appropriate real-world situation	Problem uses an appropriate and plausible, real-world situation.	Problem uses an inappropriate but plausible, real-world situation. Or Problem uses an appropriate but not plausible, real-world situation.	Problem does not use an appropriate and plausible, real-world situation.

	75+20 Problem matches equation	75+20 Problem appropriate situation	75-48 Problem matches equation	75-48 Problem appropriate situation	12 * 6 Problem matches equation	12 * 6 Problem appropriate situation	48/6 Problem matches equation	48/6 Problem appropriate situation	37.98 / 25 Problem matches equation	37.98 / 25 Problem appropriate situation	332 / 16 Problem matches equation	332 / 16 Problem appropriate situation	1/2 + 3/4 + 3/8 Problem matches equation	1/2 + 3/4 + 3/8 Problem appropriate situation	(139+143+144+154) / 4 Problem matches equation	(139+143+144+154) / 4 Problem appropriate situation	Average
Student 1																	
Student 2	3	3	2	3	2	3	3	3	3	3			3	3	3	3	2.857143
Student 3	2	3	1	2	1	3	1	1					1	2	3	3	2.071429
Student 4	3	3	3	3	1	1	1	3	3	3			1	1	3	3	2.285714
Student 5	3	3	3	3	2	2	3	3			3	3	3	3	3	3	2.857143
Student 6	3	3	3	3	3	3	3	2	1	3			2	2	3	3	2.642857
Student 7	3	3	3	3	3	2	1	1			1	3	3	3	2	2	2.357143
Student 8	3	3	3	3	3	3	3	3			3	3	3	2	3	3	2.928571
Student 9	3	3	3	3	3	3	3	3	3	3			3	3	3	3	3
Student 10	3	3	3	3	3	3			3	3			3	3	3	3	3
Student 11	2	2	3	3	3	3	1	3			1	2	1	2	3	2	2.214286
Student 12	2	3	2	3	1	1	1	1	1	3			3	2	2	1	1.857143
Student 13	3	3	3	3	3	3	3	3			3	3	3	3	2	2	2.857143
Student 14	2	2	2	2	1	1	3	3			1	2	2	2	1	1	1.785714
Student 15	3	3	3	3	1	1	1	1	1	2			2	3	2	3	2.071429

Appendix K

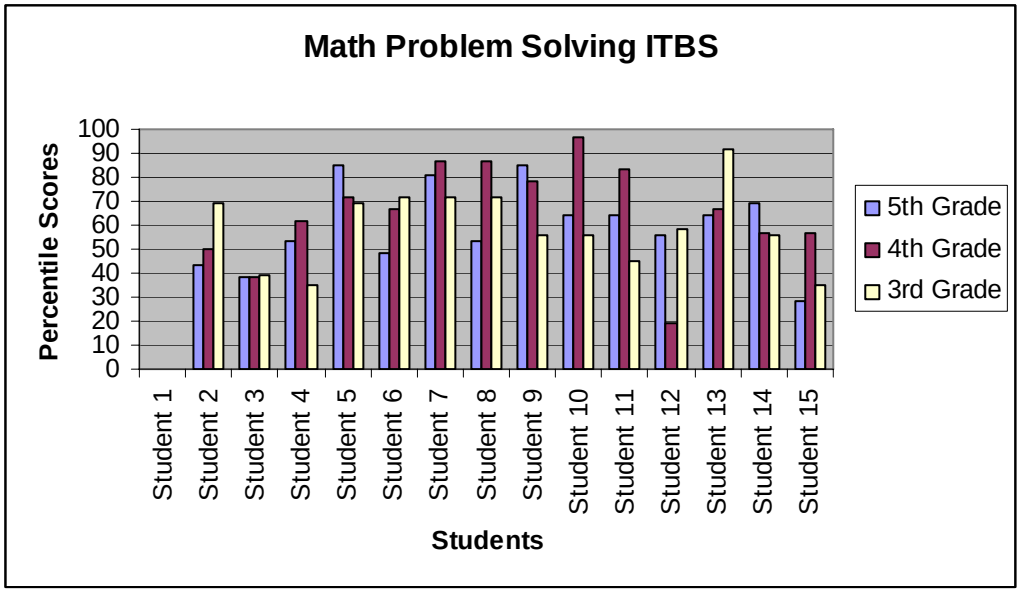
Math Computation ITBS

Math Computation	5th Grade	4th Grade	3rd Grade
Student 1			
Student 2	78	99	61
Student 3	30	79	38
Student 4	59	99	53
Student 5	23	75	31
Student 6	67	88	41
Student 7	92	98	46
Student 8	43	88	41
Student 9	59	99	35
Student 10	40	99	74
Student 11	83	96	71
Student 12	30	52	70
Student 13	83	99	34
Student 14	40	50	96
Student 15	78	99	92



Math Problem Solving ITBS

Math Problem Solving	5th Grade	4th Grade	3rd Grade
Student 1			
Student 2	43	50	69
Student 3	38	38	39
Student 4	53	62	35
Student 5	85	72	69
Student 6	48	67	72
Student 7	81	87	72
Student 8	53	87	72
Student 9	85	78	56
Student 10	64	97	56
Student 11	64	83	45
Student 12	56	19	58
Student 13	64	67	92
Student 14	69	57	56
Student 15	28	57	35



Math Total ITBS

Math Total	5th Grade	4th Grade	3rd Grade
Student 1			
Student 2	52	60	68
Student 3	31	58	48
Student 4	59	58	43
Student 5	71	77	72
Student 6	50	70	64
Student 7	79	70	71
Student 8	61	86	59
Student 9	81	86	60
Student 10	74	99	61
Student 11	52	84	52
Student 12	29	85	29
Student 13	60	65	50
Student 14	65	68	57
Student 15	26	46	38