Connections Between Communication and Math Abilities

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Abstract

In this action research study of my Class I School's 5th and 8th grade mathematics, I investigated students' connections between communication of math skills and their math abilities. I discovered that students can increase their math abilities with the opportunities to discuss their thinking as well as evaluate thinking and strategies of other students. Electronic communication can be a valuable source for students to communicate further to other students.

This research project examines the connections between students' communications during mathematics activities and the level of their math ability. I am interested in the ways students are able to communicate their knowledge and learn mathematics. In my Class 1 school I have experienced many combinations of students and grade levels. I have noticed that students that have other classmates to discuss the content they are engaging seem to comprehend more easily the tasks or skills necessary for successful learning. Students with no grade level classmates to discuss content seem to struggle more than students with classmates to discuss with. What influence does group discussion have on my students' mathematical thinking? Does my multiage setting put some kids at a disadvantage? Might electronic communication help fill the void of discussion for some students?

In this is an action research project, I am studying my current 5th and 8th grade students. For the past 12 years I have taught in a Class I school in a small rural town in eastern Nebraska. The school has grades Kindergarten through eighth grade and all are in the same classroom. Over the past decade there have been 6 to 23 students with one (me) teacher and an aide. Recently the number of students has decreased to 7. A fact of life in this setting: students are exposed to the curriculum in all grade levels. The students in lower grades are introduced to the upper grades' skills by overhearing their lessons. The upper grades have "refresher courses" when skills are being taught to the lower grades. There are many connections between subject areas as well, from grade to grade and within grade levels. This atmosphere is a prime location for students to excel.

I have taught many of the students from Kindergarten through 8th grade. Often, I am the only teacher they have had. Knowing them and their families for many years helps me see them as "whole children." I know what and how they have been taught all their lives. Seeing a

difference in children's learning is a professional concern. In the past the teachers have noticed a gap in the math ability in the students over all grade levels. A "Math Data in the Classroom" program was started to help increase the math skills of the students. Weekly quizzes are given over yearly objectives and class results are posted. This created student need and desires to learn upcoming skills. In turn the math scores improved. Over the years, however, I have noticed some students continually struggling with the ability to apply the skills they have learned to the appropriate tasks that are asked of them. I take responsibility for most of their learning and want to give each the best opportunities to learn. Some students are in grades with no same-age classmates. This has concerned me for many years. More recently I have seen a connection with the lack of communication, between students of same grade level and low level of math ability.

Problem of Practice

This year I have a grade with only one student. Abby[1] has been a student of mine for 6 years. She has had one or two classmates throughout the years, however the past two years she has had no grade level classmates. In correlation to this situation I have also noticed a lack of Abby's ability to use the skills mastered to perform tasks and a decrease in the progression of skills that she is able to do. For instance, she has mastered the understanding of multiplication but has difficulty applying that skill to multi-step multiplication problems. She can also read graphs accurately but cannot reason through comprehension questions about the information the graphs represent. I feel this gap of understanding can be due to the lack of communicating her understanding to others as well as interpreting the thinking of other students using the same skill. If I am in any sense correct about this situation with Abby, I will need to enhance

[1] All names are pseudonyms.

communicating with the students and expecting them to communicate as well. In my journal I noted my concerns early on:

> They don't seem to think for themselves. They won't go out on a limb and try or do things. I have noticed my problem with some of my students' abilities to communicate and understand the skills is not only in Math. I need to bridge the gaps in understanding by communicating with them and expecting them to communicate as well (November 2006).

The NCTM Principles & Standards for School Mathematics, under the communication standards, hold that all students grades 3-5 should be enabled to organize and consolidate their mathematical thinking through communication. They should also communicate their mathematical thinking coherently and clearly to peers, teachers, and others by using mathematical language to express ideas precisely. In this process, students should also analyze and evaluate the mathematical thinking and strategies of others.

I suspect that Abby, my only 5th grader, is lacking in these areas the NCTM standards promote due to her lack of grade level peers. She doesn't seem to see the connections from one lesson to the next. I speculate that if she had a classmate to communicate with they could work together and that this may help Abby to remember and see connections. They could analyze and evaluate each others thinking. She could demonstrate her solutions to the 8th graders, but that is still missing the evaluating of others thinking.

At this point I am considering the options for my 5th grader to communicate with other students. She needs to be able to organize and consolidate her mathematical thinking through communication with peers and using language of mathematics. She also needs the opportunity to analyze and evaluate thinking and strategies of other students. I want to know if her

mathematical abilities increase when she has a chance to communicate mathematically with others. In turn this can help other educators know and see the importance of having students work and communicate together.

It is my goal to give Abby as well as my other students the opportunity to communicate with other students about their mathematical understand and strategies. Questions that come to my mind when thinking about achieving this goal: Do students need an immediate answers or reply to their questions or requests? Do students need other students of the same age to communicate with to understand math skills? Can electronic communication be a valuable resource for students to communicate to other students?

Literature Review

Research evidence shows in national and international studies that mathematics at the middle grades is not serving many students well (Lappan & Mundy, 1993). Lappan, a University Distinguished Professor in the Department of Mathematics at Michigan State University, and Ferrini-Mundy, an Associate Dean for Science and Mathematics Education and Outreach in the College of Natural Science at Michigan State University, have chaired the National Council of Teachers of Mathematics research of characteristics of effective programs in middle grades. These grades lack a history of a clear mathematical mission. These emerging adolescents are moving from a concrete-manipulative stage to abstract thought. However, middle level students are curious and prefer active learning situations. We as educators must change from the computation-dominated curriculum to a curriculum that stresses problem solving, understanding, and applications (Taylor, 1989). Taylor's article was initially presented at a conference at the University of Missouri in Columbia with the support of the National Science Foundation. Participants' feedback was included in the final article.

The National Council of Teachers of Mathematics (1989, 1991) and Mathematics Association of America (1991) both stress the importance of students' developing "interconnected understanding" of mathematical concepts. Complete understanding includes engaging in the process of mathematical thinking, solving problems, making conjectures, explaining, justifying, and challenging.

According to the Professional Standards of Mathematics (NCTM, 1991), classrooms should encourage students to discuss their ideas, respect and value student thinking, and encourage exploration of mathematical ideas. According to Stein, Grover and Henningsen (1996), consistent engagement in thinking practices lead to a better understanding as well as the ability to demonstrate communication skills. This article focuses on mathematical tasks for mathematical thinking. A random sample of 144 tasks was used.

In development of oral communication skill, small group discussions have equivalent advantages over large class discussions. However, students are more influenced by the communication they experience than by what they are told (Smiley, 1958). Smiley is an assistant professor of education and director of the Office of Institutional Research at Hunter College. Learning opportunities arise when children attempt to communicate with each other. They learn to resolve conflicts, verbalize their thoughts, and interpret their partner's verbalizations.

Recent research also emphasizes the importance of discourse. This includes talking, thinking, agreeing and disagreeing to make sense of mathematics. Discourse is the way ideas are represented, exchanged, and modified into powerful notions. Collaborative discourse can help children clarify their own understanding by talking and by reconceptualizing their own thoughts as they attempt to make sense of their partners' explanations (Yackel, Cobb, & Wood, 1993). Yackel, Cobb and Wood, of Purdue University Calumet, Vanderbilt University, and Purdue

University, respectively, describe an experiment in which all instruction in a second grade mathematics classroom was replaced by small group problem-solving strategies for an entire school year. Children were grouped in pairs and spent half of each math period working together to solve math problems. The other half of the period was used for whole group discussions of the paired activities. The goal of the project was to foster collaborative learning and build conflict resolution skills, as well as to provide for other learning opportunities that do not arise in more traditional classrooms.

Challenging their partner's explanations, asking for clarifications, explaining why they disagree all involve organizing and reorganizing one's solutions in order to provide alternative explanations or proof. In turn they improve their understanding of mathematical concepts. Teachers often indicate that they have improved their own understanding of mathematical concepts through teaching them (Taylor, 1989).

There is evidence that cooperative learning in small groups has great potential for raising achievement of all students and reduces inequities. In small groups students have greater opportunity to discuss mathematics thus improving their understanding. Small group settings enable students to discuss their different strategies for solving problems and consider the reasonableness of their estimations.

Students in small groups can solve more difficult problems than they would be able to solve individually. With more people working on a problem, more ideas for solutions are generated (Taylor, 1989). Students need opportunities to show what they know and can do including more complex assignments that require exploring problem situations and reporting their findings (Lappan, 1993).

Students in school come to expect singular right methods for solving problems and that the teacher supplies. “Doing” math meant following the rules while “knowing” math meant remembering and applying the correct rule (Stein, et al, 1996).

The tasks used in the classroom influences the kinds of thinking processes in which students engage which then influences student learning. Teachers, all too often, find it difficult to stand by and watch students struggle and they step in to early and take away the students opportunities to discover and make progress on their own. The learning of mathematics is a matter of constructing mathematical meaning.

Communication is at the heart of classroom experience which stimulates learning. The NCTM Standards for School Mathematics lists communication second only to problem solving (Clarke, Waywood & Stephen, 1993). The focus of the discussion in this article is a study of four years’ use of journal writing in mathematics involving 500 students 7th through 11th grade.

The role of communication including writing has been viewed to enhance the learning of mathematics. Writing is a classroom activity which offers the possibility for students to develop a deeper understanding of mathematics they are learning. Writing encourages students to reflect on and explore their reasoning and to extend their thinking and understanding.

Understanding mathematics learning generally involves knowing the concepts and principles and making meaningful connections between prior knowledge and concepts being learn (Shield & Galbraith, 1998). Shield and Galbraith researched if writing enhances learning in mathematics.

I am interested in understanding better efforts to increase students’ understanding of math concepts through communication. In the preceding articles there were no small classes observed. In my teaching situation there are no students of the same grade level for all students to

communicate with. Small groups of the same grade level are impossible. Working in groups of differing abilities and grade levels is acceptable if there is not a large difference, which in my school there is a 3 year span between grade levels (5^{th} and 8^{th} grades). Also, there were no articles dealing with using technology to communicate with others. By using Internet to communicate with other teachers, classrooms, and students, groups can be formed of same grade levels. My research will contribute to the idea of communication in groups is important to the learning of math but I will also give the new idea of distance communication through Internet. Using peer oral solutions in the classroom as well as giving peer written solutions through the Internet, I will be able to see if math abilities increase. By having students work in small groups of unlike grade levels, present oral solutions, and communicate with other classrooms I hope to improve the student's understanding of mathematics. In turn this can help other educators see the importance of communication between students to improve their understanding of mathematics.

Purpose Statement/ Research Questions

The purpose of this study is to see if there is a connection between communication and mathematics abilities. Different types of communication can be used to affect the student's mathematical thinking. Data took place during the 2^{nd} semester 2007 in the researcher's classroom. The study explored the following research questions:

- In what ways do group discussion influence students' mathematical thinking?
- How does oral communication influence a student's understanding of math concepts?

Methods

I collected data for this project from February 7^{th} until May 2^{nd}. I interviewed students, copied weekly assignments, kept a personal journal, administered pre- and post- tests of mathematical knowledge, and administered two standardized achievement tests. I encountered

some problems however with the data collection. In late February we experienced consecutive snow days which delayed the student assignment collection as well as my personal journaling. In late March we administered standardized achievement test during Math class resulting in no student assignments or collection. One week in mid April we participated in a Central Community College workshop for the students, dealing with Entrepreneurship, resulting in no math classes, as well as no collection process.

I first collected data from students in the form of an interview. I developed the interview to question students of their thoughts of group discussions, justifying solutions, and communicating their mathematical thinking. After receiving proper consent, I conducted the 9 question interviews during school hours on the12th and 15th of February, 2007 (see Appendix A). I recorded the interviews for later review. After listening to the interviews I grouped responses by common themes. Later I matched these responses were with my personal journaling.

I wrote weekly teacher journals. The journal discussed topics from the classroom during math and thoughts of weekly assignments as well as using Teacher Journal Reflective Response prompts (see Appendix B). My first journal entry expressed my view of the students' feelings of the interviews. Journal during the week February 12th:

> Interviews seemed stiff. The students seem to want to answer correctly to help my research. They appeared nervous. My questions look as if to stump them as well.

I used my journal to keep track of points of misunderstanding of the content by the students as well as times of great understanding.

I copied individual assignments weekly to trace students' mathematical abilities and thinking. I looked over assignments for justifications of solutions as these afforded me insight into the students' mathematical thinking. I used these assignments to compare growth in

organizational skills in presentation of solutions and understanding of the content. An improvement in neatness of papers was also observed. The idea of their work being reviewed caused them to take greater care in the presentation of the work.

We sent weekly solutions to another classroom, by Internet, to comment on and reply with their own solutions. During the beginning of our action research project I was grouped with other Math in the Middle participants who were concentrating on similar ideas. Rachel Bunnett was also dealing with math and communication. Rachel let me know she would be willing to help in a journal response:

> I have 26 students and I know that they benefit from hearing their classmates' mathematical thinking. Sometimes hearing the solution from someone other than the teacher can be beneficial, students sometimes have a different way of getting the point across. I think your question about having her communicate electronically with other students may be a good idea, it's not face to face but may still have some of the benefits. If you'd like to try it out I know many of my students would be willing to try it.

Her school is much larger than mine and she has many students to communicate with Abby.

As Abby finished an assignment she picked a problem to provide a written solution for. She would type the problem and her solution up. I then copied it to an email page and sent the solution to Rachel by email. In turn one of her students would solve the same problem and send their solution back. Both students could then observe how the other student solved the problem. I would have Abby tell me what was done the same and what was different in the solutions. We would then discuss the advantages and disadvantages of the differences.

The 8th grade class asked for the same experience. I then asked a teacher from Math in the Middle, Cohort 1 (Doug Glasshoff of East Butler), if he would be willing to let his 8th graders communicate with my students. Many of my students will enter his school as freshmen. He too felt it would be a benefit to his students as well. The difference in this setting was the responses not only contained a solution but comments on the understanding of the solution my students had

sent to them. This gave confidence to my students to show they can explain well enough for someone else to understand.

I kept journal and assignments beginning the week of February 14th, 2007 and concluded the week of May 2, 2007.

Other data collected came from Pre and Post test scores as well as the Iowa Test of Basic Skills and the Stanford Achievement tests, Math Totals and Problem Solving scores. A pre- test was given before each unit and a post test was given at the end of each unit. This showed the growth in knowledge of each math skill taught during the unit. Three pre- and post- tests were administered. These tests were no longer then 30 problems and I was hoping to see at least a 25% increase between pre- and post-tests. The ITBS scores are from Spring, 2006 and the Stanford scores are Spring, 2007. State legislature caused a change in districts; my Class 1 school became part of a larger district. Due to this change the ITBS was no longer given but instead the un-timed Stanford was administered. ITBS had Math scores divided into sections such as Concepts/Estimation, Problem Solving and Data, Computation, and Math Total. Stanford divided the Math scores into sections of Problem Solving, Procedures, and Total Math. I asserted that I could compare both tests Problem Solving and Total Math scores. However, are these tests comparable enough to say the scores show a growth or drop? Since the Stanford was not timed I feel the scores may be incomparable. All students did stay under the recommended time, however the stress of being timed was removed during the Stanford testing.

Findings

My first assertion is that communication seems to help students stay on task, with feed-back on their solutions; it helps them understand where their thinking is off and where they made

their mistakes. In student interviews I asked what they learn by watching and listening to others' explanations of math problems.

> Darrin, an 8th grader, for instance, responds in a way that seems quite normal for him, "**How they did it, or how to do it if I don't know how to do it, and other ways to do it.**" He has never seemed very confident and does not think of the idea that his explanations may help others:
>
> Sam responded similarly, **"I can see the way they do it and compare mine to it to see how they did it differently and see if there is better way to do it so I can improve myself."** He is always one to find the best way to do anything. And he will always challenge new information.
>
> Alternatively, Linda expressed that listening and responding to others is not always a good thing. She said, **"Sometimes they can be confusing because they learned differently, different than the way I have. So it's a different explanation."** Linda indicates that this sometimes confuses her and loses what she thought she had come to understand.
>
> Amber realized another importance to group work: "**There are so many different ways people see different things."** Once students understand there is not always one way or one answer they will be more willing to try to solve problems because they will know that they can come up with their own way to solve.
>
> Natalie also saw the importance of group work: **"They (group members) help me see a new perspective and I can better understand what I am doing."**
> Unlike Linda, Natalie sees the good in being able to hearing different explanations.

The students indicate communicating verbally helps them know they are still on track. In my interviews with students, they noted that they are more comfortable with going on to the next problem when they were able to discuss their solutions with someone. During class you can hear them ask:

> "What did you get for number 4?"
> Someone then responds:
> "I got x = 5.95. Is that what you got?

If answers are different I hear the students explaining what they did, how their two solutions are different, and deciding which answer is more reasonable. The students work together and help figure out problems. Not only do they want correct answers but they also want to know how that

answer came about. Student to student communication shows that students don't always just want an answer but the process used as well. They seem to want to learn the process so they can be the one to have the next correct answer.

As for Abby, her recall seems to be lacking from day to day and even minute to minute. Without classmates to discuss she doesn't seem to think back to find what she is missing. Being the only one to answer teacher questions sometimes adds pressure to always being correct and this too may hinder her recall ability. For example, my 5th grader seems to understand multiplying decimals by 10's during teacher presentation of the lesson. When she went to individual work she made many mistakes. When I discussed with her the problem, she had the right concepts and caught her own mistake but only after she was prompted to look further at the problem.

In a journal I stated an assertion I had about Abby's lack of math ability.

> I have a feeling it has a lot to do with problem solving and reasoning.

The 8th graders have each other to compare solutions and discuss processes. The 5th grader seems to accept the first answer she gets with no analyzing or evaluating of accuracy and reasonableness. The following came from my journal entry during the week of March 13th:

> She (Abby) has the right concept, but only after I tell her to look at a problem can she find her mistakes. I think I am going to try telling her she has so many wrong answers on the page and she needs to find those mistakes and correct them. That will force her to look over her work before turning it in.

In my own experiences as a student in the Math in the Middle courses I find myself understanding how not having a classmate can hinder recall. When I struggled with a problem and I needed a hint to remind me of a skill learned in an earlier workshop to help me get started on solving the problem. After I read through discussions on Blackboard and called a classmate, I

was able to dig into the problem and complete the project. Having a classroom and classmates would have made the process easier. Clearly I understand how Abby must feel not having someone to just discuss with to get started.

My second assertion is that group discussions help students understand different ways of solving problems. When students are asked to communicate their solutions they just want to talk numbers and processes. Students don't want to explain why they feel their answers are reasonable. They can listen to other students' solutions to learn new ways of solving a problem. They don't however seem to analyze and evaluate the thinking and strategies that other students use. They don't ask questions of why. When students were asked to show their solutions at the board they stayed close to the answer and only showed exact work. There is a dilemma I face. The 5th grader was not able to comment on the 8th graders work because of the higher level content. Many times it seems she does not pay attention. The 8th graders in turn seemed unexcited about the 5th graders presentation because of the lower level content. One time when the students were asked to show their solutions an exciting thing happened. I wrote about it in a journal:

> One student knew he solved the problem completely different then the rest of the class so he was excited to show how he was able to do it different then the rest of the class. We had quite a discussion over that problem. The students did not understand how he did his solution so it took a lot of explaining in his part but finally all the students had their "I got it " light bulbs go on. It was exciting for them to understand his point. Exciting for him because he was able to make them understand his ideas. Exciting for me to see my students finally seeing the excitement that there is in Math.
>
> One student prepared a poster with her solution and even showing her work of checking for the correctness of the answer. The other students seemed impressed and even a little jealous they had not thought of that idea. I am excited for the next time I ask them to present their solutions. I am thinking of having a formal presentation from each, once a week.

Students that work together seem to communicate their solution until the other students clearly understands the concept. During the interview, at the beginning of the research, students

stated that hearing other student's explanations helped them to further understand the skills. My students stated they enjoy discussing the skills and the solutions they come up with. Even when mistakes are made the students seem comfortable discussing them as well. During preparations for presentations at the board I noticed that one student had made a mistake. I discussed with her and she fixed her mistake. When she went to present she shared what she learned from her mistake.

> Taryn said : **"When I first did this problem I had b= 1 because when I started with –1 = 2 +b I moved the 2 to the other side of the equal by adding instead of subtracting. Which then gave me the incorrect b so my final solution was wrong too. I had y = ½ x + 1 and I should have had b = -3 and my final should have been y = ½ x – 3. So be careful with your signs they make a big difference."**

The 8th graders discuss how they got different answers and decide together whose answer makes more sense and why. My one 5th grader, however, does not have anyone to discuss with. Even with my own experiences in Math in the Middle, during the school year where there is no classroom meeting - I am missing the classroom communication to truly understand the content because of the physical distance between students. Teacher led communication sometimes is too helpful and students don't have to think for themselves. In a journal I wrote my concerns about teacher led communications with my 5th grader:

> I know she understands when she talks it through but she has no classmates to talk with her so it ends up being me that she must work with. I sometimes worry I give clues in my reactions which creates a crutch she uses to come up with the correct answer. My 5th grader also is missing out on the chance of hearing other students mathematical thinking as well as the opportunity to analyze and evaluate their strategies.

Giving students more independent responsibilities with less teacher interference causes students to communicate. If a teacher does not put input into the solution but rather question like a student the active student will have to explain more to justify their solution.

> The following came from a journal entry during the week of February 22nd.

I had the students pick a problem , from the assignment, to write up an explanation to their solution. The students in the 8th grade seem to have an easier time explaining their solutions. The 5th grader seemed to be struggling for words as well as skills to explain her solution.

Abby's first practice written solution was a money problem that discussed wages per hour with an over time increase. The aide assisted Abby in the solving of the problem, while I was working with the 8th graders and Algebra. Abby was able to get the correct answer with help from the aide. When I questioned her about her solution she was unable to discuss what she did and why. Finally, she and the aide, together explained what they did and why. So she was suggested to add to her written solution to justify what and why she did things to solve the problem. During the student interview students seemed stumped by the term justify. Many felt justify only meant getting the right answer. Others said it meant to write out the problem and write out all the work.

Amber said:

"**If I get the problem wrong I can go back and find what I did wrong."**

Other students talked about other benefits to justifying their answers. Taryn said:

"**I can explain it to others or I can do more problems like that one."**

When asked if they can explain a problem to a student who was absent from math class, students verified the benefit to justifying their solutions.

Linda wasn't confident in herself, but knew she could help if she did the justifying on her own work. **"If it was a complicated problem and I had it written down I could explain it to them."**

Sam stated that justifying can help you as well as others. **"If you want to help someone else eventually then it is easier to show how you got the answer, if you just have an answer you might not remember how you got that answer."**

On April 4th I had the students start a project of sending a problem and a solution to another classroom by Internet. They in turn solved the problem and returned a solution; sometimes a comment of the differences and similarities of how both students solved the problem was included. Some students explained each step while others assumed an easy concept can be skipped over without showing their work. One of the 8th graders felt her explanation of a solution in written words would never end. She had a great detailed explanation.

Responses to the sent solutions were just as educational as the solution process itself. Students were able to see other ways of solving the same problem as well as read comments from other students on their feelings and understanding of the sent solution. Some of the 8th grade student from East Butler responses included noticed mistakes:

> For the problem, $4 + 3(/5n+1/) = 13$
>
> **The way the other student did it makes sense to me and I could follow every step, I found my mistake and understand what I did wrong.**

Some of the responses showed an understanding of how the problem may have been done a different way that may have been less time consuming:

> For the problem, Which point belongs to the graph of the solution set of the system? $x<2$ and $y< 2x +3$ a. (0, 5) b. (0, -5) c. (-5, 0) d. (-3, 5)
>
> **I did a lot more work than the other student, I did not think of plugging them in to see which one worked. That would have saved me time. I am happy that I got the same answer after all that work**.

Other responses showed that even though the solution was different the solution was written in a comprehendible way:

> For the problem, $3a + b = 4$ and $a- 2b = 6$
>
> **I chose to solve it a different way, by substitution. I could follow along exactly with what the other student wrote. They did a good job of explaining what to do. They**

ended up with the same solution that I got, but solved with a different method, addition/subtraction.

Some solution responses just showed another way to solve the problem that comes up the same solution:

For the problem, The sum of 3 and y multiplied by 3 is less than the sum of 5 and y multiplied by 5.

After reading the other students solution, I found my solution to be very similar. I moved the y to a different spot to begin with, but then we ended up with the same solution in the end.

There were also responses that showed that the solutions sent may not have been completely understood. But were still able to teach mistakes that can be made easily:

For the problem, 15 s cubed t over 3 s squared t cubed

Sam wrote: **First I started of by taking 15 divided by 3. Then I worked with the s variables. The s cubed need to be divided by the s squared. When there are exponents though you have to actually subtract them instead of dividing them. Then on the t exponents it ended up being a negative exponent. The numerator was only t and the denominator was t cubed so it made a negative exponent. To make it positive you have to put one over t squared. Then you have to multiply the other part of the equation into one over t squared. When you multiply them together, the first part of the solution goes over the t squared because they are whole numbers. So, you end up with five s over t square.**

East Butler Response: **I could follow what the student wrote for a solution, but I forgot about the negative exponents. I was a little confused by the last part. I just remembered the fact that the variable goes where the higher power was. I did end up with the same answer though. She was more detailed than me in the response.**

Abby's first experience with a response was not as promising. The problem once again dealt with money. Abby sent her solution but when the response came back the other student's answer was not the same. Abby immediately felt she had done something wrong. However she was correct and the other student was wrong. They had forgotten to use decimal and dollar sign.

This showed Abby she needs confidence and to evaluate her own and other students' reasoning and solutions. Abby does have a struggle with self confidence. Taken from the student interview:

> When asked: What do you think about when your teacher asks questions during math class?
> Abby answered: "**If a teacher asks a question I think I did something wrong."**

I have seen improvement in Abby's solutions. She showed desire to do right and explained each step with detail and care.

> For the problem, Sara has $70 and a $10 off coupon. If she goes to the Running Place and buys track shoes that cost $49.95, a stop watch that costs $24.99, and two packages of socks at $4.99 each, does she have enough money?
>
> Abby' solution: **I added $49.95, $24.99, and $4.99 x 2 which totaled to $84.92. Then I took away $10 for the coupon leaving $74.92. She only had $70 so she doesn't have enough money to buy everything.**

> Another of Abby's problems included buying 2 patches at $2.50 each, 3 magnets at $2.00 each, a cap at $8.00, 2 flags at $3.25 each, and 2 quill pens at $1.50 each at a museum gift shop. How much would you have left out of $28.90 if you bought all the items listed.
>
> Abby's solution: **I took $2.50 x 2 = $5.00 in patches. Then $2.00 x 3 = $6.00 in magnets. Then, $8.00 for a cap. Then I took $3.25 x 2 = $6.50 in flags. And finally $1.50 x 2 = $3.00 in quill pens. Now add them together. $5.00 + $6.00 + $8.00 + $6.50 + $3.00 = $28.50. We spent $28.50 in all and we only have $28.90. I took away $28.50 from $28.90 and got .40. So we only have $.40 left over.**

My third assertion is that group discussion helps create a self motivated responsibility in the students. Communication between teacher and student helps student get started but student to student communication helps keep motivation strong. The pretests given before each unit were scary for the students. Not knowing how to do something on a test is hard for students to deal with. I did observe an increase in desire to learn the content from the pretest when it came time to learn that skill. I had a hard time too during the pretests. I wanted to help too much. Then during the lessons we all had self motivation to make sure the content was learned well enough

for the post test. This teacher student communication was a great start to the motivation but the student to student communication enhanced the motivation and strengthened their abilities.

After the first pre-test, post test cycle the students seemed to stretch their abilities to complete the following pre-tests. They weren't afraid to try any skill they learned previously to complete at least portions of the pre-test.

The following was taken from a journal entry during the week of April 11th:

> The pretest was a good experience; the students were able to use what they know to figure out something new.

After each pre-test the student to student communication was exciting. They talked of the processes they tried and were excited to learn if there are easier techniques to solving those types of problems.

Achievement scores showed improvements as well. As a class the Math Total score increased 9.8% (from a class average of 77.3% to 87.1%). The 5th grader herself increased her Math Total 27% (from 66% to 93%). One of the 8th graders increased their Math Total by 33%. (from 39% to 72%). 72% was the lowest percentile for all the students in the Math Total area putting all students above average.

There was an obvious increase in the Problem solving portion of the test as well. The class increased by 8% (from 80% to 88%). The same 8th grader that had a Math total increase also had a 22% increase in the problem solving portion (from 50% to 72%). The 5th grader, too, showed and increase in the problem solving portion, 10% (from 79% to 89%). Once again 72% was the lowest percentile for the Problem Solving portion of the test putting all students above the average.

Conclusions

All this data supports the literature that I read about the importance of communication. Students are more influenced by communication they experience (Smiley, 1958). Communication including writing enhances the learning of mathematics; it extends their thinking and understanding. In turn engagement in thinking leads to a better understanding and improves communication skills (Stein, Grover, & Henningsen, 1996). Through communication the students are able to clarify their own thinking and make sense of others' explanations. With an increase in the understanding of mathematics connections between prior knowledge and concepts being taught are being made and are more meaningful. Even if students do not have classmates to communicate with writing solutions and sharing electronically may be a type of communication that will enhance their mathematical thinking. I feel a continuation and even increase in this written communication with grade level students would continue to increase math abilities as well as other subject areas. Although, across grade level solution presentations, did not seem profitable I do however feel it was a step to the written solutions by Internet that was needed and helped.

Searching for and finding a willing classroom and teacher may be the hardest part of incorporating this into a classroom. Today's students enjoy using computers and socializing with other students. Using this interest can help increase math abilities.

This data also shows that group work can generate more ideas for solutions. Students know that everyone has different ways of doing things. Working in a group can bring about more and even creative ideas for solutions. Exposure to these different ways can create an increase in individual student performances.

Increases in Achievement scores may not be the result of only this research but other factors as well. Natural intellectual growth may have caused an increase as well. Other factors

such as a change in school settings in the coming year may have placed an added incentive to do their best on the Achievement tests to prove their highest abilities. Due to a closure of the Class 1 schools my district will close the site at which I am at. All students will transfer to other districts. This will give classmates to the one 5th grader. The 8th graders will have a transition into a high school setting which will be very different from there past experiences.

Implications

I will be in a larger school district next year in the 5th grade level. However, I will not be teaching math because of departmentalizing. As a result of this research I will try to encourage my new school district to permit me to continue the Internet communications. I can inform them of the improvement I observed in the students performances as well as their scores. I can ask to use the Internet communications in other subject areas to see if this written communication increases other subject areas as well. I will however try to keep up with my students' math education, by having them write up solutions to one problem a week to inform me of the content they are learning. This can help me keep their content areas connected.

I hope to excite the teachers in my new district enough to have them try the process of Internet communication in their classrooms. We can, as a team, keep collecting data to see if the technique works in larger school settings and other subject areas.

My advice to other teachers with the problem of a lack of communication at a grade level is to find an equivalent classroom willing to communicate by Internet. Then share solutions slowly at first so it is not overwhelming. Many students will enjoy the process enough to do it on their own once we show them how. Class discussions should also be increased in classrooms. Discussions may be time consuming but are very beneficial to you and the students. You can see

and hear their understanding and students can learn from each other when they do not quite understand the skill.

I hope to follow up on the present seven students to see if their math scores increase or at least stay above average. Due to my closeness of the families this should be obtainable for me.

References

Clarke, D., Waywood, A., & Stephens, M. (1993). Probing the structure of mathematical writing. *Educational Studies in Mathematics, 25*(3), 235- 250.

Lappan, G. & Ferrini-Mundy, J. (1993). Knowing and doing mathematics: A new vision for middle grades students. *The Elementary School Journal, 93*(5), 625-641.

Mathematical Association of America. (1991). *A call for change: Recommendations for the mathematical preparation of teachers of mathematics*. Washington, D.C.: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

Shield, M. & Galbraith, P. (1998). The analysis of student expository writing in mathematics. *Educational Studies in Mathematics, 36* (1), 29-52.

Smiley, M. (1958). Do your classroom procedures really teach communication? *The English Journal, 47*(2), 81- 85.

Stein, M., Grover, B., & Hennigsen, M. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal, 33*(2), 455- 488.

Taylor, R. (1989). The potential of small-group mathematics instruction in grades four through six. *The Elementary School Journal, 89*(5), 633-642.

Yackel, E., Cobb, P., & Wood, T. (1993). Developing a basis for mathematical communication within small groups. *Journal for Research in Mathematics Education, 6,* 33- 44.

Yackel, E., Cobb, P., & Wood, T. (1993). The relationship of individual children's mathematical conceptual development to small-group interaction. *Journal for Research in Mathematics Education, 6,* 45- 54.

Appendix A

Student Interview Questions

1. What do you learn by watching & listening to others' explanations of the math problems?
2. What does it look like when you justify your answers on a home work assignment?
3. What are some benefits of justifying your answers on math homework, if any?
4. What do you think about when your teacher asks questions during math class?
5. How does working in groups help you justify your solutions?
6. Do you think hearing others' solutions are helpful?
7. Do you think it is important to explain your mathematical thinking to a math problem, why or why not?
8. Do questions raised by the teacher and your peers: help you when you are stuck o how to explain your thinking?
9. Could you explain a problem to a student who was absent from math class?

Appendix B

Teacher Journal Reflective Responses

What changes have I seen in my students this week?

What surprised me this week?

What did I learn this week that will inform my teaching next week?

How do each of the incidents relate to my research question?