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**Oral and Written Communication
in Classroom Mathematics**

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Math in the Middle Institute Partnership
Action Research Project Report

In partial fulfillment of the MAT Degree
Department of Mathematics
University of Nebraska-Lincoln
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Oral and Written Communication in Classroom Mathematics

Abstract

In this action research study of my classroom of sixth grade mathematics, I investigated the impact of an increase in student oral and written communication on student level of understanding and student self-confidence. I also investigated the changes in my teaching as I increased opportunities for student oral and written communication of mathematics. While I discovered that student level of understanding was not necessarily increased if written communications were increased, I did find that there seemed to be a rise in student level of self-confidence and understanding throughout the course of the research project due to an increase in oral communication. Additionally, my intentions as a teacher were to become less dominating as communication was increased, but the opposite occurred. As a result of this research, I plan to continue to allow oral discourse to take place in my classroom much like it has in the past.

The issue of teaching that I chose as my topic of inquiry was that of communication in mathematics. I wanted to look at both my own written and oral communication and that of my students. As sixth graders, students should be beginning to express themselves through communication, not only during creative writing classes, but also in mathematics class. Part of understanding mathematics involves being able to explain it, as I have become accustomed to with Math in the Middle. It has been my experience through Math in the Middle that I have a greater level of appreciation for problem solving when I can explain it; I retain the concepts I am learning when I can explain it and communicate it to someone else.

In my six years of experience teaching in grades 3-6, I found that my students' ability to provide a correct answer while studying a topic was not always proof that they had become proficient in the area. I cannot count the instances when I have gone back to review topics and the students cannot recall how to answer routine problems they were doing fluently less than a month ago. When they were presented with an assessment, a concept that we spent weeks on had somehow vanished from their memories. I believe that communication, both oral and written, would help in their understanding and recollection of mathematical concepts.

During my two-year endeavor with Math in the Middle, I know that when I have been selected to present a problem to the class, I made sure that I knew the problem well, and I was able to recall how to solve it because I had to present it. My solutions were carefully written out, and my speaking skills were put on display for my Math in the Middle peers to decide I had effectively communicated the problem and solution at hand. My hope in beginning this inquiry was that my students would learn to be comfortable with oral communication, both in my presence and in the presence of their peers, and that they would be able to retain their understanding with written communication. It was also my challenge to more effectively

communicate to my students the ideas of mathematical concepts and to model how their oral and written communication could enhance their learning.

Further strengthening my commitment to communication in mathematics is how it helped me come to enjoy mathematics. As a school-age student, I struggled with mathematics. It was not until college when I was given the opportunity to be a part of a new program at the University of Nebraska-Lincoln called Math Matters, that I learned how to communicate and explain my thoughts pertaining to math orally and in writing. This is when math finally started making sense to me, and it became more enjoyable. I never thought much for math until then. It was never fun. It was never important to me that I excel in it.

Rather than performing the traditional style of teaching where the teacher stands in front of the class, gives an example, instructs the class to copy the example, and finally expects that learning has taken place, I have always believed it made sense to allow students to *see* and make a connection with how and why various math concepts work. Through my research, I hoped to increase student oral communication by facilitating partner work, individual presentations, and class discussion. I also hoped to introduce written communication by modeling a write-up form that would be developmentally appropriate for this grade level. I plan to investigate the extent to which these forms of communication impact student understanding and self-confidence.

Problem Statement

Communication in mathematics is a problem of practice worth knowing about because communication is a specific process standard for grades 6-8 as identified by the National Council of Teachers of Mathematics (NCTM). It states that “communication is an essential feature as students express the results of their thinking orally and in writing...Explanations should include mathematical arguments and rationales, not just procedural descriptions or summaries” (Yackel

& Cobb, 1996, cited in NCTM, 2000, p. 268). As students are learning to be good communicators in life, it is also essential that “teachers should build a sense of community in middle-grades classrooms so students feel free to express their ideas honestly and openly, without fear of ridicule” (NCTM, 2000, p. 268). The process standard *Reasoning and Proof* calls for students to be making conjectures and generalizations and evaluating these conjectures and generalizations. Students cannot do this without effective communication. Communication also brings forth the teaching principle, which challenges me as a teacher to know what it is my students already know and need to learn, and then to help challenge and support them in these endeavors. Each content standard from *Numbers and Operations*, *Algebra*, *Data Analysis*, and *Probability* can be reached through communication.

As a mathematics teacher, it is my job to care about what the NCTM says about process standards and teaching principles, but this issue should be important to others as well. Teachers are molding students to be leaders in the world when this generation is no longer around. If students are not taught to communicate effectively, whether it is in mathematics or science or English or even politics, what kind of people will they become? Teachers and other adults should care whether they have done their very best to mold the youth to becoming great leaders and competent adults in society, whether their platform is in mathematics, science, English, or politics.

Literature Review

Communication is a multifaceted issue that is seen in all aspects of society, including mathematics. I am specifically interested in my own communication and my students’ written and oral communication in mathematics. I believe that an increase in these types of communication can lead to a deeper understanding of the mathematics being taught. Part of

understanding mathematics involves being able to explain what you have done, whether it is written on paper or stated orally to another person. I have found that I am able to retain and have a deeper understanding of the concepts I am learning when I can thoroughly explain them through both written and oral communication.

Through the investigation into related research literature that I did prior to my action research, I found five common themes: Social/Student Interaction, Mathematical Discourse, Journaling/Writing, Increased Learning, and Teacher Insight. Social/Student Interaction referred to the interaction that occurred between students and teachers when they were invited to participate in their learning. This coincided with the Mathematical Discourse theme, which specified that the interaction between students should be about the particular mathematics being learned. Journaling or writing out solutions was another theme that occurred throughout the articles I read. It seemed that when students wrote out explanations or journals in reaction to a problem or occurrence in class, their understanding became deeper. This directly coincided with the Increased Learning theme. Finally, a theme involving reflections from the teacher surfaced. Teacher Insight involved the teacher being able to recognize what had been taught and learned, as well as what needed to be revisited.

Social/Student Interaction

Communication can come in many forms. One way in which communication takes place is when students are allowed to have a voice in the classroom. This can happen through interactions with the teacher through journals, working with a partner, or standing up in front of the class to help clarify an idea that has been presented. Forman and Ansell (2001) examined the multiple voices in the discourse of a third grade classroom community by analyzing the classroom teacher and focusing on a sample of whole-class discussions. Additional information

provided and modeled by the teacher helped Forman and Ansell to respect the teacher's personal feelings and beliefs and her collaborations with her students, their parents, and other teachers. Mrs. Porter, the teacher, voiced to her classroom that, "This is a class where we all teach each other" (Forman & Ansell, 2001, p. 122). In her classroom, each student was encouraged to voice opinions. Each student was responsible for his or her own learning, and each student was as responsible as the teacher for explaining his or her ideas.

The concept of sharing ideas among students was not unique to Forman and Ansell's (2001) study. Kieran (2001) explored the co-shaping of public and private discourse in partnered problem solving with 13-year-olds. The nature of mathematics that emerged was found to be related to several factors, including characteristics of utterances made before and after solutions had been made, the degree of activity between the partners, and the extent to which the partners made their thoughts explicit and public. Kieran cited Teasley's (1995) study, which found that talking was a significant benefit to the learning process especially when it was done with a partner. Kieran found that 13-year-olds could experience difficulty in communicating their thinking to peers in such a way that the interaction was highly mathematically productive for both persons.

The multiple voices of Mrs. Porter's classroom included the parents of students, the students themselves, and Mrs. Porter. The discourse in Kieran's (2001) study was exclusive to the 13-year-olds within the study and did not include anyone outside those relationships. Within Mrs. Porter's classroom, each student was actively involved, whereas Kieran's study of 13-year-olds may have been inhibited by the willingness of some participants to bring forth their thoughts and ideas. The success or lack thereof of each of these studies may be attributed to the nature of the interaction.

Mathematical Discourse

It had long been my classroom practice that students were allowed to speak to one another about problems they were working on. Typically, they were checking to see if they got the same answer. If so, they moved on. If not, they re-worked the problem. McNair (2000) discussed the three components of mathematics classroom discourse that led to the greatest learning potential for students. The three components included subject, purpose, and frame. He suggested that for a discussion to be considered a mathematical one, it must contain each of these three components. To maximize the learning potential for students the subject must be mathematical, the purpose must be to add greater depth and understanding to students' reasoning, and mathematical frames must be used to guide the discussion (p. 206).

Others also have studied the effects of mathematical discourse within classrooms. Manouchehri and St. John (2006) used a framework to analyze the discourse in two high school geometry classrooms. They highlighted the differences in traditional classroom discussions and the discourse that occurs within learning communities. They point out that "according to NCTM, 'the discourse of a classroom – the ways of representing, thinking, talking, agreeing and disagreeing – is central to what students learn about mathematics as a domain of human inquiry with characteristic ways of knowing'" (Manouchehri & St. John, 2006, p. 544 quoting NCTM, 2000). Manouchehri and St. John also referred to Burbles (1993), who defined discourse as being a communicative relationship between peers that represents participation, commitment, and reciprocity (p. 545). Students who committed themselves to participating in classroom discussions and received reciprocating comments back from other students and their teacher will gain a deeper understanding of mathematics and maximize their learning potential.

In an attempt to gain the most from classroom participation, Mrs. Porter, from Forman and Ansell's (2001) study, among other mathematics reform teachers, replaced her classroom discussions from the traditional I-R-E (initiation by the teacher, response by one or more students, evaluation by the teacher) model to a form of discourse that "more closely resembles discussion orchestration" (Forman & Ansell, 2001, p. 118). In this type of verbal discourse, students were allowed to initiate and evaluate responses and comments made by other students; they were encouraged to respond. The students were sharing the responsibility of the teacher to explain the mathematics. A new form of dialogue was created when students are asked to journal. When teachers were able to individually comment on each student's journal, more individualized instruction and a more supportive classroom atmosphere was then brought forth. This will be further discussed in later themes.

Forman and Ansell's (2001) and Manouchehri and St. John's (2006) studies were similar in that the subjects in both characterized what it meant to have a conversation about mathematics. In both instances, the students were able to speak out in class and others were welcomed to comment back to them. Forman and Ansell's study was done in a third grade classroom, and Manouchehri and St. John's study was done in two high school geometry classrooms. McNair's (2000) research simply discussed how the three components of mathematical discourse could be used to analyze the quality of students' mathematics classroom discussions.

Journaling/Writing

Many times in my classroom I asked students to talk out loud with partners or with me and had them explain their thought processes. It was not always an organized train of thought that resulted so allowing students to write out their thoughts would help in this endeavor. Pugalee

(2004) compared oral and written descriptions of students' problem-solving processes. His purpose was to investigate the impact of writing during mathematical problem solving. Pugalee referred to Garofalo and Lester (1985) who identified four categories of behavior during mathematics: orientation, organization, execution, and verification. Certainly having the opportunity to write and edit one's thoughts would extend into the organization and verification behaviors.

Borasi and Rose (1989) found similar results in their study of journal writing and mathematical discussion. They discussed the value of engaging students in mathematics through writing and keeping a journal. During a semester-long course, students were encouraged to write about their feelings, knowledge, and mathematical processes and beliefs. Borasi and Rose referred to Yinger and Clark (1981) who observed that journals "put the writers in the position to learn (a) what they feel, (b) what they know, (c) what they do (and how), (d) why they do it" (as quoted in Borasi & Rose, 1989, p. 353). When students were put in positions such as these, the orientation and execution behaviors that Pugalee (2004) referred to were also extended.

Through the journaling that occurred in Borasi and Rose's (1989) study, the instructors realized how valuable the thoughts of each student were. Not every student was inclined to speak up in front of the class. However, through journaling, every voice was heard and given merit. Through journaling, teachers were able to individualize some of their instruction and gain students' perspectives about what topics need more attention and what the next move should be. This last idea will be revisited later.

Both Pugalee's (2004) and Borasi and Rose's (1989) articles showed students had greater understanding through writing. Pugalee's article analyzed the problem-solving processes of ninth grade students' written and oral descriptions, while Borasi and Rose emphasized a writing-to-

learn perspective through journaling. Here it was suggested that the journals had the potential to contribute to the teaching of mathematics through self-reflection, forming dialogue between the students and teacher, and an improvement in the teaching of the course that resulted from the instructor reading the journals.

Increased Learning

“Teachers need to help students develop the belief that they as individuals are responsible for understanding and sharing mathematics” (Manouchehri & St. John, 2006, p. 550).

Communication is one way that teachers can achieve this task. When students are allowed to discuss, elaborate, and comment on ideas in a classroom setting where discourse is prevalent, they will gain their own understanding, rather than waiting for ideas to be validated by a teacher in the typical I-R-E model classroom. Through discourse, students can be responsible for their understanding and learning.

Borasi and Rose (1989) commented that students seemed aware of the learning benefit of journal writing and often use their journals without being instructed to do so to gain from this benefit. One student in their study commented, “I have been able to realize what I am doing wrong in my thinking process. Once I know what I am doing wrong, I have been able to change and thus do better” (Borasi & Rose, 1989, p. 357). Another student said, “I am able to see on paper my thought process toward problems instead of some abstract thought in my mind which are hard to keep” (p. 357). Reflection in this capacity solidifies the idea that student learning will be increased through writing.

An increase in learning through discussion was also achieved in Eisen’s (1998) study. Eisen set up his biology course at Emory University such that each class was divided into two halves; the first half consisted of his presentation of the background of the topic of the day, and

the second half consisted of a student actually presenting the topic of the day. The result that Eisen hoped to achieve was that students would learn communication skills and learn from each other. Through these student presentations, students became more active in the learning process, and they learned to effectively communicate to a large group. Certainly they did learn the content from each other through this sort of communication too. The teacher, though still an active part of the class, was less dominating, while still offering guidance and allowing the students to be responsible for the learning in the classroom.

Borasi and Rose (1989) suggested an increase in learning was the result of student self-reflection through journal writing. Eisen (1998), however, used the students' verbal communication to bridge the gap between traditional student-teacher relationships where the teacher's role was to present mathematical material while the student's role was to absorb it. In this aspect, Eisen strove for the students to "gain ownership of their education" (Eisen, 1998, p. 54).

Teacher Insight

When teachers were willing to give up some control of the goings-on of their classrooms, there was a wealth of insight that could be seen through their students (Borasi and Rose, 1989). Teachers who learned to listen to their students' comments and ideas not only learned which way to further guide the instruction of the class, but also sometimes saw concepts in a whole new light. Teachers should learn to rely on the dialogue that takes place with students to monitor their progress and help decide what the next move should be (Manouchehri & St. John, 2006).

Forman and Ansell (2001) commented that Mrs. Porter felt that if she taught the children to use strategies that made sense to them, not just the ones that Mrs. Porter was most comfortable with, they would be able to build their confidence in mathematics. If her students used their own

strategies to solve problems and were not forced to use just one approach that possibly did not make sense to them, Mrs. Porter believed they would also build on their informal knowledge of math. By allowing students to have a voice in the classroom, teachers can also get to know each student individually. This can lead to an improved evaluation of the content being learned and more precise remediation for individual students who need it (Borasi & Rose, 1989).

The three studies done by Borasi and Rose (1989), Manouchehri and St. John (2006), and Forman and Ansell (2001) each devote considerable discussions pertaining to the knowledge that is gained from a teacher's standpoint. A common theme among the three articles is that teachers have nothing to lose and everything to gain from listening to their students, reading their students' thoughts, and allowing their students' ideas to be explored.

Concluding Statement

My study was an analysis of the types of communication that took place in my classroom and the understanding that came from trying to increase communication. I hoped to hear my students make comments that suggested they had gained a better understanding of the mathematics I was teaching. I also hoped to see evidence of greater self-confidence after students had been allowed to verbally participate in discussions and in writing.

Many of these previous studies took place in classrooms that contained students in high school and college, while mine took place in a sixth grade classroom. Although Eisen (1998) had students present the topic for the day in a biology class, my students had prepared solutions for specific problems that covered mathematics topics we already had learned. Like Mrs. Porter in Forman and Ansell's (2001) study, I will encourage my students to use strategies that make sense to them, not just the ones that make sense to me. I hoped to allow more discussion to take place about strategies that were being used. My hope for this study was to find that my students

could thoroughly understand and explain their ideas to the class as a result of increased oral and written communication.

Purpose Statement

The purpose of my study was to find out whether an increase in my students' oral and written communication could improve their level of mathematical understanding. In my inquiry, I sought to understand how students proceeded in their thought processes and in turn become convinced that their solutions were valid and correct. I also was interested in understanding how my students' self-confidence changed as these forms of communication increased. The questions I addressed in my inquiry were: 1) What will happen to students' level of understanding as written and oral communication is increased? 2) What will happen to my mathematics teaching as written and oral communication is increased? 3) How does students' self-confidence in solving math problems change as written and oral communication are increased?

Method

To begin this study, I made a data collection timeline for the purpose of keeping my data collection on task and organized. I collected data during the spring semester of 2009. The timeline gave information concerning each research question, the data collection procedures to be executed for each research question, the frequency of the data collection for each research question, and the duration of the data collection for each research question. I prepared surveys, rubrics for scoring oral and written solutions, interview questions, and guiding questions for my personal journaling. I also constructed a calendar of dates, times, and students to be interviewed to keep my interview process progressing and to remain within my time frame.

I collected data through pre- and post-research surveys, daily journals noting observations, weekly journals, oral and written solutions from the students, individual

interviews, and daily work. The pre-research surveys were given on February 3 before beginning any other data collection (see Appendix A). The identical post-research surveys were given on April 24 after all other data had been collected. At the culmination of my data collection, I made a tally chart and tracked each student's answers to generalize their self-confidence (see Appendix B).

Daily journals noting observations were written two to three times per week beginning February 4. At the end of each week, I reflected on the week's happenings and recorded this in a weekly journal. These were written and kept directly in my research journal. The last journal entry was written on April 25. Journal Prompts that I used can be found in Appendix C.

Approximately 1-2 students presented oral solutions to the class about once per week within the timeframe of February 4 through April 24. Written solutions to the daily problems of the day were turned in by the students and scored on seven separate occasions also within the timeframe of February 4 through April 24. Both of these sets of data were scored with identical rubrics (see Appendix D). The rubrics, however, did not seem adequate in assessing the effect of oral and written communication because each problem was so different and the rubrics were too general.

Five class sets of daily work from Chapter 10 were collected during this time as well as three class sets of quizzes for chapters 7, 8, and 10. To analyze these I took note of which problems were frequently missed and what types of errors were made. I did not collect any daily work from the other chapters we worked on, and therefore it was difficult to decide whether progress was made in regard to student understanding and student level of self-confidence. It seems that success really depended on the content of the chapter I was teaching at the time.

Finally, I conducted 21 interviews between March 6 and March 31. Each of my 14 students participated in an individual interview gaining information on student level of understanding (see Appendix E), while seven students were randomly selected to participate in a second individual interview gaining information on student self-confidence in solving math problems (see Appendix F). Interviews were each transcribed for easier analysis. To analyze the interviews that gained information on student level of understanding, I paid close attention to what students could tell me about math vocabulary and how they approached each of the two problems. While analyzing the interviews that gained information on student self-confidence in solving math problems, I paid special attention to the answer that students gave regarding working in groups and their attitudes toward solving the math problem presented.

There were several occasions that inhibited my data collection. During the 60-day data collection period (counting only weekdays), there were 17 days in which collecting data was impossible: five days were scheduled as non-school days, there was one snow day, eight days were taken for assessments, two days a substitute was present, and another day math class was canceled. Three days were also devoted to chapter tests, while the day before each test consisted of working on the chapter reviews. It also was customary in my classroom to allow the students to make corrections to their tests for a better grade the day following the test.

The changes that I made to my teaching to incorporate more oral and written communication included student-led discussions regarding the problems of the day and allowing for agreement and disagreement from others. Additionally, approximately 10 minutes each day was devoted to giving students time to write out their solutions to the problem of the day on an individual piece of paper to be turned in to me. The first few times I introduced having students write-out solutions consisted of me providing a structured format similar to, "First I did this

because...Next, I did that because..." It was difficult at first for the students to remember exactly what step they did first, or to even put their thoughts down into words on paper. A task that continued to be difficult for the students was stating why they performed a specific function. My presentation of material did not change much. I continued to seek student input as I have in the past.

Findings

An average day in my classroom began with the students solving a "Problem of the Day." Ten to 15 minutes were usually allotted to this activity. Once everyone had a sufficient amount of time to work on the problem of the day, we began discussing it. I usually asked for volunteers that I had noticed with adequate solutions to present their solution at the board. After one or two students had presented their method of solving the problem, I usually asked if anyone else solved the problem differently. It was exciting in my classroom when different ways were presented.

After the problem of the day was discussed and presented, I liked to review what was taught and learned the day before. My math series, Houghton Mifflin, offered a "Lesson Review" and a "Lesson Quiz" section at the conclusion of each lesson. Often the students were asked to work the simple computation problems offered in these sections. When ample time has passed, these were also briefly discussed. If homework was assigned the day before, we corrected it together, and I tried to answer any questions that may have surfaced from the homework.

The largest portion, approximately 30-35 minutes, of my math class was dedicated to the teaching and learning of the lesson. I began by presenting the content of the day by asking questions to generate student ideas that will lead to the discovery of the content instead of the I-R-E model (Forman & Ansell, 2001), which gives away ideas with no student thought. I tried to

make a connection to past lessons to make it easier for the students to build content knowledge. When there was math vocabulary that will need to be remembered, I had the students take notes. Vocabulary was always discussed and examples were always given to help recognize and differentiate between vocabulary terms.

After explaining the content, as a class we practiced working some of the problems from the text with the students putting answers on personal whiteboards for me. This involved the students on a higher level by allowing them to hear the process, see the process, and do the process. When I thought the students understood the concept, we moved on to individual or group practice. At this time they also got immediate feedback from me when they held up their whiteboards to show me the answer they got. Usually this process allowed me to seek out individuals who needed personal assistance.

Finally the homework assignment for the day was assigned. On days that consisted of group practice, I encouraged students to discuss the problems with their neighbors and solve them together. Some students still chose to work on their own. I tried to allow class time to begin the homework; however, there are times when we ran short on time. In these instances, it was up to the students to complete the homework on their own.

What will happen to students' level of understanding as written and oral communication is increased?

I was hoping to find that student homework and test scores would increase due to an increase in oral and written communications, as well as an increase in rubric scores for oral and written solutions to in-class problems and problems of the day. However, my data were inconclusive. I looked to my teacher journal entries, surveys, rubrics for both oral and written solutions, homework and quiz scores, and interviews to assess this question.

My teacher journal entries seemed to indicate students beginning to look to their peers for explanations, rather than just the teacher. I thought this represented a deeper understanding of the content, as my students no longer only looked to me, the teacher, to affirm their answers. In particular I noticed one group involving four girls, Carla, Melinda, Alisha, and Liza¹, who really took to talking over problems with each other. For example, on March 24, a day when partner work had been assigned, Carla and Melinda were working together. I heard Carla tell Melinda that an answer was not right. Melinda asked, “What? Why?” and Carla explained. Neither of the girls asked me to verify. Marie and Ashton also had some good conversations. Usually in their case, it was Marie directing Ashton, who struggled quite a bit more in math. Marie really did a great job of trying to explain to Ashton how to work a problem.

The pre-research survey that I gave showed 13 of the 15 students I had at the beginning of my research responded with an answer of sometimes (6), usually (3), or always (4) when asked if they understand math topics better when another student explains it in addition to the teacher’s explanation. In the post-research survey, the results were identical, except that I only had 14 students at the conclusion of the research. This tells me that my increase in communication did not hurt my students’ understanding.

While I hoped my oral solutions would show an increase in rubric scores during my intervention, the scores for the 31 oral solution presentations across the duration of my research did not show an increasing trend. Similarly, the average scores for the written solutions for each problem of the day that I scored were 10.9, 8.2, 13.5, 11.3, 10.4, and 14.1. All of these too had a possible score of 20 points. The rubrics (which were identical for both oral and written solutions) were too general while each problem was very different. On four of the six days that I scored written solutions, students were missing, and there was always at least one student who would

¹ All names are pseudonyms

not put forth any effort. Both of these points suggest my data here was insufficient and therefore inconclusive.

I collected five homework assignments. The average score for the first and second assignments were 71% and 76.7%, respectively. The third assignment had an average score of 85.2%, however, one score was missing. The average score for the fourth assignment was 82.5%, and the fifth assignment collected had an average score of 80.6% with three scores missing and one thrown out because the student had an IEP and only did a small portion of this longer assignment. Missing assignments were student responsibility and at the end of the year, these assignments had never been turned in. The level of motivation also had an impact on homework scores. On April 24, my teacher journal states that I had become frustrated with the lack of motivation among my students to complete their homework assignments and put forth effort. The averages of the three tests were 92% for chapter 7 with 15 students contributing (one student moved away shortly after beginning research began), 80.2% for chapter 8 with one student score missing, and 78.64% for chapter 10 with all 14 students accounted for. The test scores showed that instead of an increase in scores, there was a decrease. Chapter content and degree of difficulty of the material may have been a contributing factor here.

During interviews, some students tended to forget or become confused about the meaning of simple vocabulary terms like quotient, sum, difference, product, numerator, and denominator. Six of the 14 students said that when they do not know the meaning of a vocabulary word it sometimes stops them from solving the problem, and eight of the 14 students said it would not stop them from attempting the problem. Many stated that they would use context clues to help them understand the word's meaning or the problem itself. In light of my research question on understanding and due to the interventions I implemented, I interpret this data to mean that in

general my students attempt to solve problems that they do not fully understand in hopes that understanding, or a correct answer, will come. During the interviews, only one student stated that he did not understand the problem that was being presented. In his case, not understanding the problem stopped him from attempting the problem.

How does my students' self-confidence in solving math problems change as written and oral communication is increased?

During the research project my students became more willing to make attempts at writing or orally explaining solutions. Even on occasions when their solutions were incorrect, their self-confidence was not diminished. We discussed how their ideas were valid so they did not feel discouraged and unwilling to make another attempt. For example, on March 8, my students were working together with manipulatives to add or subtract customary units of measure and orally explaining solutions to each other. I noticed Carla and Melinda having good conversations with each other. I was pleased with the friendly dispute the two girls were having about how to regroup from quarts to cups. The problem was:

$$\begin{array}{r} 1 \text{ gal } 2 \text{ qt } 1 \text{ cup} \\ - \quad \quad \quad 1 \text{ qt } 3 \text{ cups} \\ \hline \end{array}$$

Melinda thought that when she regrouped from quarts to cups that because there are 4 cups in a quart, the cups should now be 4. Carla argued that it should be 5 because the 4 cups just brought over from the quarts must be added to the 1-cup already there. I was impressed that even though Melinda was not correct, she did not become frustrated and stop; she kept going and accepted that Carla's explanation was correct. Carla did not become belittling toward Melinda either. They both simply moved on to the next problem.

On several occasions, my journal entries note the confidence in oral presentations was on the rise. On March 29, I stated, “This week, I was impressed with the students’ willingness to give suggestions and ideas as to how to solve an area/perimeter problem that involved more than one ‘shape.’ I also was impressed with Ashton speaking up in class the next day.” On April 19, I stated, “I was surprised that Marie did as well as she did with not having been in school all of last week.” Marie had presented the first problem to a homework assignment, and though she had been absent and missed the instruction for this lesson, her confidence was not inhibited. She was still willing to attempt her explanation. She scored a 13 out of 20 on the rubric usually using correct vocabulary, offering some explanation, and taking steps toward the correct solution. I believe Marie did not feel that the other students would ridicule her if her answer was incorrect.

On April 24, I noted in my journal how Luke, a usually shy student, “really surprised me on Monday with his reasoning and insight into the POD (Problem of the Day) 10.6. He did a great job of explaining it to me and with some prompting also did well in front of the class.” On April 13, I was feeling very frustrated with my research feeling that nothing had come from it so far. Then reverting my previous statement, I said, “Actually, thinking back to my interviews, it seems students’ confidence is up, however not much has happened with their level of understanding.”

During my March interviews, each student was very willing to orally explain solutions to me. In an interview with Lisa, she had to explain how to solve the problem “two-fourths times three plus four times two and one-fourth.” Even though her final answer was incorrect, she did not stumble in finding her answer. The interviews for gaining information on student level of self-confidence yielded these results: 3 of the 7 students said their self-confidence in using math

skills in or out of math class was at an 8 on a scale of 1-10. One student put their confidence at a 9, another student at a 10, and two students put their self-confidence at a 5.

To increase written communication, I modeled during class how I wanted written solutions to look. Previously, students were having a difficult time during class even putting their thoughts into words and writing them down on paper. After modeling the format I wanted students to use, Luke seemed to be more willing to try just because he had some type of direction. In Appendix G1 is Luke's ill attempt at reasoning on paper. He includes his thoughts, but they are not mathematical thoughts. He writes, "I also think it is because evens are better in my opinion." An example of Luke's later attempts at writing his solution can be seen in Appendix G2. He follows the format I modeled by saying what he did first, next, then, last. Christopher was also able to write out in sentences what information he knew, what he knew would work, and what he deemed the final solution. This suggests that Christopher's confidence in writing had increased. Before modeling how I wanted written solutions to look, Christopher did little more than write the answer on his paper (see Appendix H1), and he had a difficult time putting into words what it was he had done to solve the problems. An example of Christopher's later attempts can be seen in Appendix H2.

Yet another example of student confidence occurred during a lesson on analyzing data for stem-and-leaf plots. Students were asked to find the range of a set of data. I asked the students to help me find the range. After we found it, Melinda asked, "Now, don't we divide by 2?" Even though she was incorrect, she was not shy about putting forth her thoughts. Melinda is not a shy person in the social aspect of school, but in the academic aspect she generally is a student who does not volunteer questions or information in front of the class. She previously tended to seek private help.

There was another day when we had been reviewing area and perimeter of rectangles, and I had the students working with partners to complete a worksheet. I decided to do one problem in particular together as a class because they had not yet seen a problem like it. It showed two rectangles put together to form a “T” shape. Dimensions were given on four sides of the shape and the task was to find the area and perimeter of it. On this day, it seemed that my interventions for this research had fallen by the wayside. Rather than calling on students for ideas, I was asking students to volunteer their ideas instead. It seemed that this served my students and me well. Their confidence in speaking up was more on display.

I began by asking, “Does anyone have any idea how we might find the area of this shape?” Christopher responded with “Well, you could fill in the other sides.” “Okay. Let’s do that. It will help us find the perimeter later.” Even though he was not correctly giving information to find the area, he was still thinking about the task as a whole. I did not want to deny him of his good idea. It definitely was something we would need to do later, even though we were working on area first. We *could* have done perimeter first. Another student then chimed in and said, “Six times eighteen and six times twelve.” He was meaning that first we would need to find the area of the first rectangle (6×18) and then find the area of the second rectangle (6×12). Melinda asked, “What about the three?” In choosing to address the other student first I said, “Yes, 6×18 and 6×12 , then what? Should we add? ... Do we need the three? ... No, why?” It was days like this, when most of the students were engaged, that I believed, in light of my research question pertaining to student self-confidence, progress was being made in student self-confidence through the increase of oral and written communication.

I noted in my journal “I enjoyed then watching some of the groups come up to the board to work problems together.” Many times they did not ask for my input. They discussed together

how to solve the problem and each of them watched the other respectfully and then answered the question, confident that they were correct. I have found that an increase in oral and written communication has positively impacted student self-confidence.

What will happen to my mathematics teaching as written and oral communication is increased?

During this research project, I found that as a teacher it was difficult for me to become a facilitator of oral communication and allow the students to take the reigns over the class. I still wanted to guide and direct the students in the right direction and by doing that, my role in the classroom became more prominent and directive, rather than peripheral and supportive like I had hoped. During class, there were days when I found myself doing more teacher instruction than I would have liked, instead of allowing the students to explore. On March 3, I wrote, “Have them explain tomorrow. Too much teacher instruction today!” After an oral solution, I tended to reiterate what the presenter said and then ask if there were still questions regarding the problem rather than allowing the presenter to do so. However, it is in my nature to ask the students to “help me out” in solving problems. I struggled with giving up too much power and letting the students guide the class. It seems my greatest difficulty during this research project became allowing that increase in oral communication among students to take place.

After students took the Quiz/Test for Chapter 8, I allowed them to redo any missed problems to get half credit back. Ashton, who struggles greatly in class, originally got a 55%. After reworking problems, she only answered correctly 2 of the 12 she missed without my help. I pulled her back to my classroom during study time and helped her to correctly answer the other questions by guiding her. I refused to allow her to make the same mistakes again. This also is typical of my usual practices. In respect to this research project, I should have allowed Ashton to

make the mistakes and rediscover the content on her own. I feared though that this would cause a drop in her already low self-confidence in math.

During interviews, I found myself not wanting to settle for incorrect answers from the students, so I questioned again and again if they were sure about their answers. If they continued to say yes, I then asked, “what about...?” I hated to let my students solve the problems incorrectly. I would let them show me their thought process to a certain point, but I would redirect them once it got to a point where their thinking would get too far off track if they continued. I asked prompting questions to get them back on the correct path. An example of this from Brenna’s interview follows. The question stated, “The condos on Galaxy Avenue are numbered from 1 to 140. How many addresses contain the digit 6 at least once?”:

T: What are you thinking?

B: Uh, 6, 16, 26, 36,

T: What would be next?

B: 46, 56, 66, 76, 86, 96, 106, 116, 126, 136.

T: Good. Do you think you have them all, 1 to 140?

B: I guess.

T: Um, I’m gonna have you look at this number right here. 66. Are there other numbers that have a 6 in the tens place?

B: Yes.

T: Because you listed all the numbers that have a 6 in the ones place. What other numbers have a 6 in the tens place?

B: Um, 6? What?

T: In the tens place. This is one’s, this is ten’s, right?

B: ...60?

T: Mmmhmmm. Any others? Go ahead and write 60 down. What comes after 60?

B: 66.

T: If you’re counting by ones?

B: Oh, 61.

After I questioned Brenna, she understood what she had forgotten in the problem, and she correctly answered the question.

Conclusions

In conclusion I found that it did not necessarily matter if written communications were increased; student level of understanding was not necessarily increased because of it. It seems that my findings were not quite what Pugalee (2004) found in his research, that an increase in understanding can result through writing. However, I do believe that if I had more time to work with my students on written communication, their written communication would have served them better in regards to their level of understanding. I had hoped they would write their reasoning and thought processes for choosing those specific computations over others. Instead, it was a struggle to get them to write more than simply the computational steps that were taken to solve the problem.

Student level of self-confidence did seem to be raised throughout the course of the research project due to an increase in oral communication. I believe that I was able to successfully build on my students' knowledge and reinforce the idea that their thoughts were important even if they were not necessarily completely correct. This coincides with Mrs. Porter's idea from Forman and Ansell's (2001) study that students and teachers both teach each other, as well as the idea that "Teachers need to help students develop the belief that they as individuals are responsible for understanding and sharing mathematics" (Manouchehri & St. John, 2006, p. 550). When students are allowed to discuss, elaborate, and comment on ideas in a classroom setting, they will gain their own understanding, rather than waiting for their ideas to be validated by a teacher. When students are involved in oral communication discourse, they become responsible for their understanding and learning.

With regards to this research project, my teaching has come to a point where I am listening to my students, but I halt them before they get too involved in a solution that will take

them in the wrong direction. I feel that while my intentions were to become less dominating as communication was increased, the opposite occurred within my teaching. Eisen (1998) was able to succeed in fading into the background and offering guidance when needed. Before this research project, I believe that I was a presence in my classroom, not quite as in the background like Eisen, but less dominating than I became as a result of the research. For reasons that I have difficulty putting into words, I did not want to give up much control during the instruction portion of my class.

Implications

As a result of my study, I plan to continue to allow oral discourse to take place in my classroom much like it has in the past. I also plan to still encourage students to work together on class work and homework. I believe from prior classroom experience and personal experience that often times a greater understanding of mathematical content is achieved when a peer can explain the concept in addition to the teacher's explanation. I would like to try to incorporate math journals in my classroom along with written solutions without the stigma of having to rely on a rubric to score the solutions. If I include rubrics in the future to score solutions, they would need to be greatly revised to include more specific points pertaining to each specific problem, rather than using one general rubric that does not quite speak to all of the problems we solve in class. This study has convinced me that working to increase oral and written communication in my mathematics classroom is worth the effort in dividends it pays in student understanding and confidence.

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Appendix A

Name (optional) _____

Pre- and Post-Research Survey for Gaining Insight Into Student Self-Confidence:

	Strongly Agree			Strongly Disagree	
1. I like it when my teacher calls on me to give explanations in Math class.	5	4	3	2	1
2. I like it when my teacher shows us different ways to solve problems.	5	4	3	2	1
3. I like it when my teacher encourages us to find different ways to solve problems.	5	4	3	2	1
4. I like presenting my solutions to the class.	5	4	3	2	1
5. I am able to explain solutions to my peers in class to help them understand mathematical concepts.	5	4	3	2	1
	Always	Usually	Sometimes	Never	
6. I understand the math topics that we cover in class as they are taught.	4	3	2	1	
7. I understand the math topics better when another student explains it to me in addition to my teacher explaining it.	4	3	2	1	
8. Please give a sentence or two telling me about your attitude toward math. Do you like it: yes or no? Why or why not? If you like math, do you think you are more confident in math? If you dislike math, do you think you are less confident in math? Why or why not? (You may use the back for more room.)					

Appendix B

Pre-Survey

	5	4	3	2	1
Q1	III	II	IIIIII	II	I
Q2	IIIIII	IIII	II		
Q3	IIIIIII	III		III	
Q4	III	II	III	II	III
Q5	III	III	IIII	II	I

The data shows that most did not care if they were called on, most liked the teacher to show different ways of solving problems, most enjoyed the challenge of solving problems in more than one way, there was a range of disagreement on the enjoyment of presenting solutions to the class, and most could explain topics to peers in class.

	4	3	2	1
Q6	II	IIIIIIII	III	
Q7	III	III	IIII	II

The data shows that most students usually understand math topics taught in class, and most students sometimes or usually think it helps when other students explain.

Q8 Most students like math because it is challenging. They are confident because they know the teacher will be patient and re-teach if they do not understand.

Post-Survey

	5	4	3	2	1
Q1	II	III	III	III	III
Q2	IIIIII	III	II	I	
Q3	IIIIIII	III	I	II	
Q4	III	III	III	III	II
Q5	III	IIII	IIII	I	I

The data on question one is evenly spread; some students like to be called on while others do not. The other data varied very little from the pre-survey.

	4	3	2	1
Q6	I	IIIIIIII	IIII	
Q7	III	III	IIII	I

The data on questions 6 and 7 only slightly varies, most likely due to the transfer of one student to another school.

Q8 Students were still confident and know math will be used outside of class.

Appendix C

Teacher Journal Prompts:

1. What changes have I seen in my students this week?
2. What surprised me this week related to oral and written communication in mathematics?
3. What went really well this week related to oral and written communication in mathematics?
4. In what areas could I have improved my communication this week. What could I have done differently?
5. What have I done differently to encourage more student communication?

Appendix D

Oral/Written Solutions and Reasoning for Problem Solving, 6 th Grade Math, Mrs. Sample			
Stronger than Weak		Weaker than Strong	
4	3	2	1
A great understanding of the mathematical content is expressed.	A good understanding of the mathematical content is expressed.	Little understanding of the mathematical content is expressed.	No understanding of the mathematical content is expressed.
Mathematical vocabulary is used effectively and naturally.	Mathematical vocabulary is used in a familiar way.	Very little mathematical vocabulary is used.	No mathematical vocabulary is used.
Mathematical vocabulary is used correctly all of the time.	Mathematical vocabulary is usually used correctly.	Mathematical vocabulary is sometimes used correctly.	Mathematical vocabulary is never used correctly.
Computation is exact and systematic, making the solution and thought process easy to follow.	Computation is correct and there is some explanation for finding a solution.	Computation contains errors and there is little explanation for finding the solution.	Computation is incorrect and no explanation is given for the solution.
Presents an informative explanation of the skill.	Present an explanation of the skill that takes steps toward the correct solution.	Presents an explanation of the skill that is hard to follow.	Presents an explanation of the skill that is vague or confusing.

Appendix E

Student Interview Questions for gaining information on student level of understanding:

1. Before we begin, is there anything I should know about you to better understand your problem solving in math or your general math experience?
2. When working on a word problem, do you think you know the meaning of most of the vocabulary words in each problem? Please give some examples.
3. Why is it important to know the meanings of vocabulary words you see in math? When you see a word in a story problem that you don't know the meaning of, what do you do? Does not knowing a word stop you from solving the problem? Why or why not?
4. I would like you to work on this problem, saying aloud whatever you are thinking as you work through the problem. I especially want to hear you talk about how you decide what to do to try to solve the problem.

While weighing fruit, Michelle finds that 6 apples weigh the same as 2 grapefruits and 2 kiwis. A grapefruit weighs the same as 8 kiwis. How many kiwis weigh the same as one apple?

5. I would like you to write a solution to this problem, trying to write down all your steps and explain what you are thinking. Afterwards I will ask you how you decided what to do to solve this problem.

The condos on Galaxy Avenue are numbered from 1 to 140. How many addresses contain the digit 6 at least once?

Appendix F

Student Interview Questions for gaining information on student self-confidence in solving math problems:

1. This semester I have changed some of my teaching practices to include more student communication. What advice would you give me about continuing these changes next year?
2. What do you think about when I, or another teacher, ask you questions during Math class?
3. On a scale of 1-10, with 1 being the least confident and 10 being the most confident, how confident do you feel about using Math skills in or out of Math class? Give an example of how you use Math outside of class.
4. Has your attitude about working word problems changed during your 6th grade year? How?
5. Did you enjoy working word problems before this year? Why do you think this was the case?
6. Do you prefer to work by yourself or with a group? Why?
7. If I were to ask you to explain how to solve a specific math problem step-by-step, would you be confident in showing me how to do so and explaining why you are performing specific tasks?
Okay, walk me through this problem:

$$2\frac{1}{5} \times 3 + 4 \times 2\frac{1}{4} \quad (\text{two and one-fifth times three plus four times two and one-fourth})$$

Appendix G1

if you multiply an even number
by any counting number is the product odd or
even

Luke
G1

~~10~~
~~x 7~~
~~70 odd or even~~

~~10~~
~~x 2~~
~~20~~

$$\begin{array}{r} 8 \\ \times 7 \\ \hline 56 \end{array}$$

Even

$$\begin{array}{r} 8 \\ \times 3 \\ \hline 24 \end{array}$$

$$\begin{array}{r} 8 \\ \times 8 \\ \hline 64 \end{array}$$

$$\begin{array}{r} 6 \\ \times 6 \\ \hline 36 \end{array}$$

$8 \times 7 = 56$ I think it is even because
there are more evens
when you count and even \times even
= even

and I also think it is because evens are
better in my opinion

Appendix G2

Luke G2

Probl

3, 6, 9, (12)

4

4, 8, (12)

3

6, (12)

2

I took all of the sums
and got 3, 6, 9, (12) ect.

Then I took 4 and got all
4, 8, (12)!

Next I took all the sum
6 / 6, (12)

Last I configured th
and every 12 days +

Appendix H1

Christopher
H1

If you multiply an even number by any counting number, is it odd or even?

It is always even when you multiply an even number \times any counting number because even numbers do not go into odd numbers evenly.

Ex: $2 \times 6 = 12$

Ex: $7 \times 4 = 28$

Ex: $9x$

Appendix H2

Christopher
Ha;

2.2
7.49
+ 9.99
+ 9.99
27.47

Chris J. Ha

29.90
~~30.00~~
- 27.47
2.53

I added \$7.49, \$9.99, + \$9.99 and got \$27.47, I did this because I knew when I added them all to get her then I could subtract the sum from \$30.00 which is the money he has and get \$2.53.

Chris J. Ha

