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Inquiry
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I. Background Information

As I sit and reflect on my mathematics education in elementary school, I have memories of timed tests, worksheets, textbooks and correct answers, or in my case, incorrect answers. I never seemed to understand what was going on with the numbers and symbols on my paper. Most of the time, I struggled to find ways to get the correct answers. It certainly did not matter if I understood *why* I was getting the correct answer and that answer was the most important part of solving a problem. In my learning experiences in math, I was encouraged that there was one correct answer. There was no discussion about how the answer was found or the thinking and reasoning to solving the problem. With these experiences, I became more intimidated by math, as I grew older. I was not usually confident in my answers for fear that they were wrong! In addition, I was unwilling to take risks, try challenging problems and in reflection, I even saw myself avoiding real life situations involving math.

At the start of the year, I predicted that my least favorite class would be math education. I was not looking forward to teaching math, let alone learning *how* to teach math. I was wondering how I could enjoy teaching something that, in my experience was intimidating, difficult and frustrating? However, to my surprise and excitement, the math education class and my experiences in the classroom have opened my eyes to what math education really can be. This year I have learned first hand that teaching math is exciting, unpredictable and engaging. These three qualities are part of what makes teaching so

enjoyable. I have become aware of teaching practices that encourage thinking, explaining, learning, and lead to understanding, rather than simply correct answers. Now, as a teacher of math, I have realized how crucial it is, that my own students do not feel as I did for so many years. It is important to me that my students understand concepts in math and feel comfortable to ask questions, discuss concepts and develop as math thinkers and problem solvers. It is important that students are able to think for themselves and really understand material presented to them. I believe that it is my job as a teacher to guide students in understanding.

My realizations about how I think my students should learn, are supported and originated in large part from background research, class experiences and teaching experiences. As I explored various professional resources, I was looking for research findings concerning what is believed to help students think and understand at a deeper level. As a teacher of second grade, addition and subtraction are two concepts that are taught and must be mastered by the students. In an article entitled *Promoting meaningful mastery of addition and subtraction* Postlewait states, "Teachers should provide activities and experiences that develop a conceptual understanding of number and operations instead of simply focusing on the memorization of rules and procedures" (p. 354). This is a strong statement that supports my philosophy and thinking about teaching mathematics. It is important that as students think about math, they are focused on the process, rather than the product. It is with understanding of the process that a product may come naturally. "The teacher should create an environment in which mathematical understanding and fluency are fostered" (http://www.css.edu, p. 2). Research also supports the idea that students should be encouraged to analyze, evaluate and use

concepts they are taught (http://css.edu, p. 1). This type of learning will be encouraged with, "Questioning strategies that are not answer-driven, but rather question driven" (Southeast Comprehensive Assistance Center). I also considered research concerning various accepted questioning methods. I researched and read this information so that I would be able to compare this information with my own data. After reading this research, I considered some of my own teaching practices.

I remember the first time I taught math to my second grade students. I had forty-eight eyes staring at me as I attempted to teach a new math concept. As I planned my lessons, I was thinking about questions to ask my students. After exploring and learning about various mathematics teaching methods, I thought about how I wanted the questions I asked my students to really challenge them to think and then also comprehend. During initial reflection on these lessons, I was unsure of how I was helping or discouraging my students to think and express understanding. I was unsure if I was feeding them answers and leading them to conclusions rather than being a guide. An important part of my teaching philosophy is that I want to be a teacher who asks questions to encourage thinking, understanding and explanation. This role is complicated because it is unpredictable. There is no guarantee for where the students might take a concept, or where students might get lost. This is the beauty of teaching, but can make on the spot decisions, questions, and probes that much more crucial. In this realization, I was led to an initial wondering.

How do the questions I ask affect the discussion that is had among my students in mathematics?

Which teaching and questioning strategies will be most effective in encouraging my students to think?

How can I use a math talk or discussion to help my students gain deeper understanding?

Are there noticeable differences in the students' understanding with different teaching techniques?

Are there differences in the types of questions that I ask my students?

Am I acting as a guide for my students or am I leading them to the correct answers?
Do my students see differences with the way lessons or questions are presented?

Is there a way that I can encourage more of my students to be comfortable sharing during math time?

Do my students enjoy being challenged during mathematics? Do they feel that they are challenged?

II. Inquiry Plan

Once I developed my wonderings, I began taking note of the questions that I asked during various math lessons. An observer wrote down each question that I asked and if able, the student response to the question. I decided to start inquiry here because I needed to know what I was doing as a teacher. I needed to collect data on the questions I asked to see if they matched with the learning I experienced in methods courses and the research I had been exposed to. As I was collecting this data, I continued to read literature on questioning strategies and math teaching methods. I also consulted professionals within the field concerning specific math teaching methods.

Specifically, I was interested in the math talk. Math talks are utilized to encourage students to solve problems, think about concepts, verbalize thinking and work cooperatively with classmates. With my initial wondering of how I could better help my students understand, math talks seemed to be a teaching method that fit my wonderings. As I did background research on questioning and teaching strategies, I collected data within my classroom on myself as an educator. It was helpful that as I was doing

research, I was thinking about the lessons I was teaching. Although I knew that this research gave me insight into my questioning strategies and ways to make my students think, my realizations came later during my analysis of my own teaching practices.

At the start of my inquiry project, my second grade class was beginning working with fractions. For the first lesson scribed, I planned three broad questions to ask my students. Purposefully, I only planned these specific questions so that I was able to have freedom and my true questioning and discussion strategies would become apparent. Over the course of the fraction unit, each math lesson that I taught, each question, and each student response was recorded. A list of the questions can be found in Appendix D. I taught the lessons in different ways in order to search for different questioning patterns. For example, some lessons were whole group, while others were small group. In addition I collected data of the questions I asked individual students. The majority of the inquiry was set up in my classroom during the fraction unit and then continued through to the multiplication unit. My class also worked with probability for a short time during my inquiry project. I chose not to analyze the questions that I asked until it was time to draw my conclusions. I felt that it was necessary to collect a large sampling of data before trying to alter my methods. As a lesson was taught, I typed all of the questions that I had asked and wrote brief self-reflection notes about how I thought the lesson went. These brief self-reflections were a way I collected data (See Appendix E). As a teacher, I believe that sometimes we have an incorrect feeling on how a lesson is going. I was able to compare actual data, to my own feelings. The main focus of my data collection within my classroom was simply recording the teaching and conversation strategies that I used.

However, I felt that I needed a student perspective on mathematics teaching and learning in addition.

I chose to gain this perspective through a student survey. Attached, is a copy of this survey (Appendix A). The survey consisted of five questions. The first two questions focused on asking my students to decide if they were comfortable or uncomfortable with various aspects of math class. I chose to have them make a choice between comfortable and uncomfortable so that there was no gray area. These questions asked the students if they felt comfortable sharing or answering in class and trying new strategies. The third question of the survey was aimed at determining whether my students had a concept of what might be considered a more difficult question. I presented the students with a passage and then asked them two questions to determine which was more difficult to answer. One was a low level question (Question A). With this question, the answer was found within the text. The second was a question that required inferring and drawing a conclusion. The students were asked to decide *why* this one was the trickier question. With this portion of the survey, I was interested in seeing if what my students perceived as being difficult was what I also would consider a more difficult line of questioning. This portion of the survey was helping me to look at one of my wonderings, *do my students notice differences among the questions asked or teaching method used?*

An important aspect of my inquiry is how my students feel during math class. Just as my first two questions investigated my students' comfort level, the fourth question also targeted this aspect of their feelings. Are my students willing to answer tricky questions during math class? This was an important question also because of the variety

of math levels within my room. There are a number of students in my room who consistently demonstrate significant, in-depth understanding of math concepts. Through this data collection, I hoped to find out whether it was only these students who felt comfortable to share and attempt tricky questions.

A final question on my survey centered on determining my students' self-perception of themselves as math thinkers and problem solvers. Do my students think positively about their abilities? This survey was an important piece of my inquiry data as it allowed me to understand student perspective. It was imperative that my data was not only focused on my own perceptions, but also the students.

Additionally, I used various pieces of student work as data (Appendix B). The students participated in activities that required them to write explanations about mathematical thinking. I used these in order to consider, as a whole, if my class was making connections. I was able to use this data to compare and contrast it to my observations and self-reflections.

The variety of data collection strategies that I utilized allowed me to have a large amount of data to analyze and use to draw conclusions. I was analyzing how my students were able to use verbal math conversation in written form. Field observations, student surveys, student artifacts, and consulting professionals and professional resources have allowed me to gain insight into my initial wonderings and questions.

The first data that I analyzed was field observations. I looked at the questions that I asked and analyzed them for patterns. I was analyzing to see if I was able to categorize the questions that I asked. I was able to separate my questions into three categories. One category that I found was direct questioning. These were the times when I asked my

students a question and was looking for one specific answer. For example, *how many pieces of pizza are in my pie?* This question results in one answer and I did not require additional explanation. A second category was questions that had one correct answer but differed from the first in that I followed these questions by further asking a student to explain his/her thinking. For example, when solving number strings, I asked my students to explain step-by-step the process they went through to arrive at an answer. This category was set apart from the first because the questions were often more in-depth and required explanation. However, a third category of questioning that I asked my students was open-ended questions. These questions did not have a specific correct answer, but were rather focused on conversation about mathematical concepts. For example, *what is a fraction?* This is a question that encompasses multiple ideas and may lead to conversation. I coded my questions by highlighting them to see if I asked one category of question more than the others. In coding them, I found that the three categories were evenly represented throughout my lessons.

In analyzing these three categories, I realized that all three of them played important roles in my lessons. My direct questions allowed students opportunities to answer without explanation. These questions allowed me an opportunity to ask for choral responses. These choral responses were instrumental in helping my students remain on task throughout a lesson. Questions in which the students were asked to explain their thinking helped me to better see my students' thinking and understanding. During these questions, there was little conversation, but it was an excellent gauge for my teaching. I also asked students questions that created a conversational atmosphere in the classroom. These were open-ended questions that required the students to articulate real-life

explanations, experiences, or to explain thinking. I realized in my analysis that it was with these questions that conversation was most encouraged. Additionally, it was these lessons in which understanding seemed greatest and students seemed most engaged.

Research supports higher level thinking questions, however, as I analyzed the data I needed to decide what kind of effect higher level thinking questions were having on my students. As I read the field observations of the questions that I asked, the math conversation that occurred during the lessons played back in my mind. In my analysis, I was able to consider points in which I felt that my students were being challenged and were thinking and times when I felt the conversation was lost, I was not connecting with my students, or the students were not connecting with one another.

One lesson in which conversation was helpful was during one fraction lesson; I began the lesson by asking the student to brainstorm what they believed equivalent meant. We talked as a small group and I wrote ideas on the board the students created a web of ideas. This was an opportunity for students to discuss knowledge on a subject. I allowed this conversation to continue as I taught the lesson. As I taught the lesson, I asked questions based on what the students were responding to. It was a neat experience because the students were learning essentially on their own, using me as a guide and questioner. In my self-reflection I noted that the students appeared to gain an understanding of fractions.

In contrast, during another fraction lesson, I asked an increased number of direct questions. I found that my students were answering questions correctly, but surprisingly in my reflection, I did not feel that the students demonstrated as great a deal of understanding. I noted that students appeared restless and unengaged. As I considered

all of my data, I was looking for discrepancies such as this. However, it was not this data alone that assisted me in drawing my conclusions.

After evaluating my questions and lessons, I looked at the surveys my students completed. I created a chart of the different responses to search for a pattern or answers that occurred most often (Appendix C). This was the most surprising of my data. In analysis, I found that twenty of my twenty-four students felt comfortable answering a question in class for which they were unsure of the answer. This shows me that most of my students feel comfortable in my classroom. I have realized how important classroom community is within a classroom. This partially speaks to that community because students are willing to take risks. Two of the four students that answered being uncomfortable are shy and rarely participate in discussions. When asked if students felt comfortably or uncomfortably to utilize a new strategy, only six of my students stated discomfort. Two of the six of these students require extra help and are provided assistance in learning support. The results of this question were encouraging because I realized that if, as a class, we have a conversation about strategies to solve a problem, my students are willing and open to trying a new way of thinking!

Another question concerned whether my students were willing to answer tricky questions in discussions. Once again the majority of my students stated yes! Six out of my twenty-four students were unwilling to attempt tricky questions. Four of the 'no' answers were from the same students as answered 'uncomfortable' in the previous two questions. This told me that the survey gave me consistent results and that I could be concerned about a small number of students. Although it is important that some of my students are not comfortable in class discussion time, other student responses I received

told me that most of the students were comfortable and loved answering tricky questions in class discussion settings! Below are samples of some of the students' responses:

"I choose yes because I love to think hard."

"Most of the time I will guess even if I am not right."

"I picked yes because it's ok if you get it wrong."

"I think I would because if I mess up someone will help me."

"Yes because I am used to discussing hard things in class together."

These questions helped me to gain insight into how my students view the atmosphere in the classroom. I found that for the most part my students were comfortable during class discussions. This tells me that my classroom has an atmosphere that encourages conversation, discussion, and thinking. Therefore, after realizing this, it was necessary to consider how I could encourage this in my teaching.

I also analyzed student work. The student work that I considered was an activity in which my students were required to create a multiplication story, draw a picture to match, and then solve the problem. The children were also asked to explain the solution process. In reading the students' explanations, I was able to see if students were able to write down explanations for thinking. Research supports the idea that "We need to make mathematics meaningful and show how language can work mathematically" (Gough, p. 2). Some of the students were able to explain in great detail a method for solving. However, in looking at explanations, I also realized that it is difficult for some students to write down what they think. It is important that writing about math and conversations about math work together to help a student understand. This was an important piece of data because conversations must be supported by written ideas. In looking at student

work, it became obvious that some students, who had difficulty writing, still had an excellent grasp on the concept. I was able to tell this from the conversation I had with my students. In retrospect, if I had not had conversations with my students, some of them may have lost understanding. This understanding could have been lost if a child was unable to express using written skills. For example, I have a child who struggles to read and write. However, in mathematics, he excels. In this math activity, had I not conversed with him, I would have not been able to gauge his understanding based on his written explanation. His written explanation showed little comprehension.

This made me realize that if the verbal aspect of the lesson had been missing, not all of my students could have gained a complete understanding. Although it would be ideal for all students to demonstrate understanding both verbally and in writing, I was able to realize that in this case, conversation was crucial.

Through my data analysis I was able to draw conclusions concerning many of my initial wonderings.

III. What I now know

After analyzing my data I was able to establish four claims from my data.

1. It is not simply the questions that I ask my students but more importantly how I respond once my students answer a question. This may determine if I foster conversation or discourage conversation.
2. If this discussion is to occur, students must feel comfortable. Once a comfort level is broken, discussion ends for that student or possibly the class.

3. Teaching and questioning strategies that focus on students understanding the process, rather than the product encourage growth and learning. Growth and learning occur when the student and teacher see this as the goal.
4. The questions that I ask my students are not about me as an educator but are more importantly about my students.

Claim 1:

As I analyzed the questions that I asked my students I realized that the original questions that I asked my students were not nearly as important as how I responded to student answers. When I responded and encouraged conversation and discussion, my students were able to gain more in depth understanding of a math concept. For example, I taught a lesson on probability. During this lesson, I asked students to give me examples of when we might use probability outside of math class. The students thought of examples such as the weather, the lottery, and playing a bingo game. I decided to use the weather as an example. I asked my students to consider a scenario. If there is a ninety percent chance that it would rain today, should I bring my umbrella? The students responded that I should bring my umbrella because there was more of a chance that it would rain than a chance that it would not rain. The students' response is, in essence the correct answer. However, it was important that the students realized that there was also a chance that it would not rain. I brought this up and encouraged my students to talk about probability in a more in-depth way beyond simply likely or not likely. As I taught the lesson, I questioned my students' answers and forced them to explain and think about probability in different ways. I could not have predicted how my students would respond

to my initial question. However, after I asked my initial question, I encouraged deeper thinking and classroom conversation in my responses to their answers. It seems that in this classroom conversation I was able to guide my students to understanding.

After I ask a question and a student answers it, how I respond changes the atmosphere of the classroom. I should ask questions with the intentions of encouraging my students to think and consider the concept. Embedded within my questions is an attitude. Is my attitude helping them and their ideas to feel reinforced and valued? In order for my questioning to be effective I need to make sure that my students know that they are valued. Perhaps Burns best says this, when she states, "Asking good questions is an informative process that needs development, refinement and practice. Teaching through questioning is interactive and engages students by providing them an opportunity to share thinking. The classroom should be a community of collaborative learners whose voices and ideas are valued" (*Questioning Strategies*, Burns, p. 23). This idea of collaboration is key in my teaching. As the teacher I should find a way to ask questions and probe conversation that encourages thinking and understanding but also allows students to develop ideas and conclusions. This development is affected depending on how I respond to my students.

Claim 2:

The math discussion that took place during many of my lessons occurred because students were comfortable to talk and share ideas. If students are not comfortable to share, than there is no way for students to express ideas and draw conclusions. This idea is also supported by research. "Questioning and conversation is interactive and engages students by providing them with opportunities to share their thinking. It involves tasks

that elicit, engage, and challenge each student's thinking" (http://www.css.edu, p. 4-5). In my classroom, the students expressed in the student survey that they do feel comfortable sharing and discussing. I believe that this is part of the classroom community that has been established and built throughout the school year in my classroom. Because there is a strong sense of community, students are, in general not afraid to be wrong or try new strategies. This creates a wonderful opportunity to have the students in my classroom converse with one another to learn and grow as thinkers.

However, what I have also realized is that once this comfort level has disappeared for a student, conversation will stop and that child, or possibly the entire class may be unable to continue the discussion. I realized this one time as I was teaching a lesson on attributes.

The students were working on determining the rules for a "guess my rule" game. This particular game asked the students to determine two different attributes to classify students. It was a challenging task that relied heavily on classroom interaction. Students needed to work off of one another's ideas to solve the problem. This task was difficult for the students and I noticed that many of the students were raising hands and just simply guessing, not necessarily drawing logical conclusions. As the teacher, I became somewhat frustrated with the situation. I did not see my students thinking about how to solve the problem! One little boy in my classroom raised his hand. I called on him and he paused and had a silly look on his face as he sat and thought for a minute, looking around. I was thinking that he was going to throw out another wild guess! As he was thinking, I stated, "Make sure we are really thinking now." As soon as I said that, the boy's face turned red and he quickly said, "never mind" and decided not to participate or

make a guess. I realized that at that moment, I broke the comfort level for that child in the discussion. He was afraid to answer and pulled out of the lesson and conversation. For him, he was no longer willing to share ideas or attempt an answer. For this child and possibly others, being wrong, became not okay! Here, I had reverted back to a teaching method that had so discouraged me as a learner.

If discussion stops, I do not see how thinking and understanding may occur. As the teacher I reacted and stopped the thinking of a student. If I stop my students from thinking during math conversations, how can I expect them to learn, develop, and grow as math thinkers?

Claim 3:

When thinking about mathematics, it is not always the correct answer that is the important part in learning. Can a child explain to you *why* 2 + 2 = 4? Mathematics cannot simply become memorization but must focus on understanding the process. The process means understanding how to arrive at a conclusion and or answer. The arrival at a correct answer that is supported by an understanding of the concept, and is not simply a correct answer is crucial.

I believe that it is important that my students understand the process of how to perform a mathematical task. However, an important question is whether my students felt the same way. In my survey, when the students were asked if they were willing to try new things, answer difficult questions, or try a new strategy, my students responded that they were comfortable and willing to do these things. This shows me that they are aware that it is not whether the correct answer is said, but whether they are able to understand the concept. This is particularly highlighted when my students explained that it was fine

to get a wrong answer. Many of them even stated that they knew someone would help them, or we would talk about it as a class. This is important evidence to consider when demonstrating that the students are able to see process over product. When the students focus on the process and my teaching methods focus on the process, learning may occur more naturally. If I as the teacher focus on my students coming up with the correct answers, the focus and atmosphere in mathematics class will change.

Claim 4:

When I began this inquiry project, I was focused on my own teaching methods. How could I as an educator ask effective questions? Was I challenging my students? However, as I have come to a point of analysis, I have realized that while I plan my lessons and the questions that I ask my students, the focus has shifted to their thinking and understanding. The focus is not on me as an educator, but on how I am guiding in their understanding and growth. The questions that I ask and teaching methods that I use should focus on meeting student needs. It is valuable to self-reflect and consider your actions as an educator. However, it is also important to consider these actions in terms of the students whom you are teaching.

IV. Additional Wonderings

One of the main things that I have realized from this inquiry project is that as I teach, there is always a moment in which you have to make a decision on where to continue with the students. Often times students will not pick up on a concept. Because of various constraints within the classroom, such as time, when is it the right time to tell the answer to the students. Students are not always able to draw their own conclusions and it is often necessary to pull ideas together for them and assist them as they draw connections and

gain understanding of a topic. However, there is a fine line between when the right time is to jump in and when to stay out and allow exploration. Giving no guidance to students may cause confusion and frustration. Allowing students little opportunity for conversation, debate or a chance to discuss will make a learner who is focused solely on correct answers rather than a mathematical process. However, between these two extremes there is a possibility for a different math teaching method. This method is one in which teacher guidance, student conversation, and interaction are encouraged and are the norm. This conversation I have found is where needs may be met and learning may occur. This learning is a result of teacher questions, teacher responses to student answers, and classroom discussion and conversation.

In my future teaching practices I must consider this thought. Each class of students that I have will be different. Perhaps different types of conversations will work best for some and not others. As the teacher, I must make decisions. Not only this, but I must step in and guide as needed, step in and lead as needed, and step out and allow exploration as needed.

Depending on situations, students, and material, teaching will be different; I believe that if I stay focused on encouraging conversation in my classroom, students will be able to draw connections, conclusions and deeper understanding in mathematics.
As I conclude my inquiry project, I cannot help but to continue to have additional wonderings. For example, when is it the right time to lead students to the correct answer? How will I determine what type of discussion will work for different groups of students? Will a sense of classroom community always carry over into other subject areas? How can I be sure not to squelch a child's thinking? Are there other ways to encourage math

thinking aside from conversation? How could I utilize a math conversation in multiple areas in my teaching? Would these other conversations be effective?

It is with these wonderings that I end my inquiry project and think about my future teaching practices. Although this project has led me to additional questions, and unanswered wonderings and ideas, I must be reminded of one of my own inquiry claims. Process over product is most important! As an educator, I must continue to analyze my practices and think about how I teach. As I think, analyze, and reflect on my own process as a teacher, the product will only come naturally.