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Generating Interest in Mathematics through Discussion in the Middle School Classroom

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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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Generating Interest in Mathematics Using Discussion in the Middle School Classroom

Abstract

In this action research study of my classroom of 8th grade algebra, I investigated students' discussion of mathematics and how it relates to interest in the subject. Discussion is a powerful tool in the classroom. By relying too heavily on drill and practice, a teacher may lose any individual student insight into the learning process. However, in order for the discussion to be effective, students must be provided with structure and purpose. It is unrealistic to expect middle school age students to provide their own structure and purpose; a packet was constructed that would allow the students to both show their thoughts and work as a small group toward a common goal. The students showed more interest in the subject in question as they related to the algebra topics being studied. The students appreciated the packets as a way to facilitate discussion rather than as a vehicle for practicing concepts. Students still had a need for practice problems as part of their homework. As a result of this research, it is clear that discussion packets are very useful as a part of daily instruction. While there are modifications that must be made to the original packets to more clearly express the expectations in question, discussion packets will continue to be an effective tool in the classroom.

I was very interested in observing the relationship between mathematical discussion in the classroom and student interest in mathematics. I was inspired to research this topic because of Math in the Middle. My favorite aspect of the Math in the Middle program is working with and alongside my peers. I have learned so much from their thoughts and ideas when discussing mathematics in our classes.

This topic related to the state of my classroom at the time in that I was unable to get students to discuss with purpose. It was as though I was telling them what they needed to know, and because they were good kids they would listen. There was something missing though. It was the students! They *are* the classroom; what was I thinking when I would talk throughout the period and not hear from them?

I began creating mathematical discussion in the classroom by simply facilitating more informal discussion during class. Students appeared to be more interested, but I was not certain how I was going to *measure* their interest. I knew that there had to be more structure, and therefore I created a discussion packet for students to record their thoughts and ideas about the discussion topic. I had a theory that facilitating discussion in the math class would help my students in many ways, mainly in that getting students to interact with one another about what they were learning would allow them to have a better understanding of mathematics.

There was a positive response to the packets. Students appreciated time with their peers to discuss the topic that we were learning about in class. I was very excited to see the response. I did find that I was heavy on discussion sometimes and missed assigning practice problems. Students were frustrated at times because they missed the practice. However, once I found a balance between the two, the students found the packets to be a great tool.

Having effective discussions in my classroom is what I focused on as my problem of practice as there were so many avenues to explore within this topic. Not only did students learn to think about mathematics as more than computation, but they also took away skills in social interaction.

I valued middle school students learning where they fit in and in what roles they feel comfortable. I held that exercises in discussion in a math class would help the students 1) find their strengths and weaknesses in terms of leadership and 2) help them define their roles in a working group. The discussion exercise would allow students the right to work on their weaknesses so they could leave the class feeling confident in ways they never have before. I realized that my job was first to help students with math, but also to value their role in society and help the students realize their potential in that aspect as well as in a math class in particular.

The focus of my problem of practice is how to better structure discussions in the classroom. If I wanted students to be able to identify their strengths and weaknesses both in math and in peer interaction, they needed a structured environment in which to do so. How did I provide purpose to the discussion? How did I convince my students that having mathematical conversation is very important to their understanding and learning? Many teachers believe that "it's not the answer that is important it is *how* you get the answer." However, these students have been trained to bubble in the correct answer and to regard what they did to get the answer is irrelevant. One facet of the problem, then, is to persuade them to adopt a completely different way of thinking. Another aspect of the problem of practice that was important was whether or not facilitating this change of thinking was even effective. This knowledge was important because it required a lot of effort and preparation to get the students to perform as a team and to discuss and write

about their thinking; I wanted to know if it was making a difference. In that regard, I attempted to assess whether or not the import of process and not necessarily product was helpful in their classroom problem solving.

Before the project, the state of my classroom could have been described as slightly chaotic but with the best of intentions in terms of discussion and written mathematical thinking. My last bunny problem (a word problem that takes a closer look at the Fibonacci sequence) was a perfect example of my classroom environment. Students were still not getting what I wanted out of the end solution; I found myself spoon-feeding them ideas and, shamefully, even giving some groups the answer. I resorted to these options out of frustration, and because I felt badly for them. Finally, as a last resort, I created a rubric that clearly stated and outlined the expectations. Usually I fear that rubrics might restrict creative thinking; I am always afraid then that students will not necessarily perform creatively, but they will perform the way the *teacher* wants so they can get an "A".

My ideal classroom discussion has many exciting components. First, students will define their goal. They will work to find a true understanding of the problem. They will analyze the problem. I want the small group of students to identify what the question is asking and then to be able to restate the problem in their own words. Then I expect the students to identify their strengths and weaknesses and either use their strengths to their advantage or work on their weaknesses and develop better skills. They will ask themselves questions such as "How do *I* fit into this problem?" or "What can *I* do to help?" Then I want them to constructively brainstorm ideas on ways to solve the problem. During the brainstorming process they will respect each other's ideas and *respond* to the ideas of others.

Once they have all of their ideas communicated in writing, they will sort through them and choose to work one or two avenues, eventually reaching a solution-- right or wrong. After they have reached a solution as a group, they should be able to convince others of their thinking and their solution. They will be able to communicate their findings with confidence and will be able to show understanding in their group's work.

Problem Statement

The effectiveness of classroom discussion in a math classroom is a very important topic to know because many math teachers tend to shy away from listening to what their students have to say. For many, it is easier to talk all period and teach them the teacher's way of doing things. Their work is then easier to grade because they all use the same method-- the teacher's method. If a teacher were to open up their classroom to some discussion then they would have to learn other methods and challenge their own thinking.

Not only is classroom discussion important because it offers a platform for math students to share their ideas, but it is critical for understanding as the students work through their thought processes. When the teacher is talking the whole class period and students offer short answers here and there then the students are lacking the time to actually think through the problem and make their own mistakes. Instead, the teacher is up at the white board guiding them through the problem. In this case, the teacher is not letting them correct themselves or even think for themselves.

As math teachers, we should care about this problem because in most other classes students are asked what their opinions are about the topic at hand. In a literature class, for example, they are asked their opinion about the author's thoughts. In social studies classes they are asked to offer their point of view on a time in history. In science they are asked to hypothesize about what will happen next. All too often in math the

students are asked to listen and offer short answers as the lesson is given. Rarely is there a math classroom in which students are asked their opinion of what should happen next. It is a disservice to our students to not provide them with the same opportunities many of their teachers have had while working on advanced degrees alongside their peers.

Literature Review

In investigating oral communication in math class, I am especially interested in whether or not communicating with one's peers about mathematics will help with one's understanding of mathematics. In fact, the articles I have read say that there is a benefit in understanding. The study conducted by Roberts and Tayeh concludes that students benefit from reflecting on their thinking by being able to perform better in future problem solving. In addition, they state that encouraging students to write about their problem solving gives educators better insight into their students' thinking. Roberts and Tayeh (2006) say, "When students write about and reflect on their own thinking, it makes a significant impact on their ability to solve problems now and in the future" (p. 236). An instructor may be interested in student journaling as a way to measure student learning. It is promising to read that there is importance in this.

There are three main themes found repeatedly in the literature. The themes are questioning, the role of the teacher in the classroom, and promoting and encouraging discussion in the mathematics classroom. These themes relate to student attitude and involvement as well because in order for a student to be involved, he or she needs to feel safe and have motivation.

Questioning:

Tanner studied 17 high school math students and the use of the Socratic Discussion in the classroom. Socratic Discussion is a form of reflective discussion. The

results of the study show that reflective discussion caused students to be more insightful and more logical in their mathematical thinking. In the article "Promoting and Studying Discussions in the Mathematics Classroom" Tanner (1998) states that "with a questioning strategy that is designed to affect inductive student reasoning, it is critical that students attempt to answer questions and not just hear answers given by others" (p. 342). The teacher needs to have the classroom skills to allow students to feel safe and confident enough to participate. Not only do teachers need these skills, but they also need to ask the right questions, namely the questions that will induce an answer from their students.

In their article, Springer and Dick (2006) discuss discourse in the mathematics classroom. They highlight three goals to meet for teachers who wish to have mathematical discussion in their classroom. The goals for teachers are to talk about what mathematical discussion should look like, to establish discourse techniques, and finally to meet teacher needs and concerns. Not only do questions serve a purpose for the teacher, but the questions also, according to Springer and Dick, "create further opportunities for other participants to continue" (p. 106). This is a significant point to consider. What, as a teacher, can one do to get the students chatting about math? What kinds of questions can be asked that will get a response which encourages others to participate? Effective questioning is a difficult skill to master. Researcher Taber (2006) studied teaching fraction concepts with the use of the story Alice in Wonderland. There is a useful example of effective questioning in the Taber's article entitled "Using Alice in Wonderland to Teach Multiplication of Fractions." While the article's title seems unrelated to the topic at hand, the article itself offers many examples of effective questioning. One scenario described shows how the teacher questions so that she understands the thought process followed by Nina, one of her students. The line of

questioning and conversation follows up with another student, Alan, adding more to the discussion. The article does not describe in detail *how* the teacher is questioning to get these results, but it is clear that the effective questioning used is a skill many teachers would find useful. This leads very nicely into the next theme found in the literature: the role of the teacher.

The Role of the Teacher:

Springer and Dick (2006) describe the teacher as having many roles in the classroom. A teacher may have the idea that students need to "discover" things for themselves. It becomes a classroom management nightmare when it is left up to the class. It really does make a difference that the teacher has a significant role in the classroom. Springer and Dick describe the roles of the teacher as choreographer, stage manager, director, and dancer.

Koenig (2001) discusses how teachers engage students in mathematical thinking and why it is important. She emphasizes key points such as leading questions, summarizing, and paraphrasing in classroom discussion. Koenig says it is clearly not enough for the teacher to stay out of the way. One may think teachers often get into thinking they need to let the students do it without them when, in fact, they need to be a big part of the discussion.

According to Koenig (2001), the teacher has the most important role. Teachers have to guide their students through the discussion and give them a goal or a vision of the end result. Koenig determined that there are four essential characteristics to a teacher's discourse moves. The four elements are purpose, setting, form, and consequences. There are moves and plans made by the teacher with *purpose*. Math teachers often think that finding what page number the homework is on and deciding the objective to be taught is

planning. In fact, planning the conversation about the homework is so much more effective. Anyone can tell students a homework assignment, but the art of having them discuss and interact about mathematics is so much more meaningful.

Koenig (2001) also focuses on “wait time”. The reason for this is because it is important to give the students a chance to participate in “the dance”, which is how Koenig describes classroom discussion. Koenig states that a simple wait of three to five seconds moves the question from one which is rhetorical to one that invites students to engage in dialogue. Often teachers struggle with this wait because they don’t want their students to feel uncomfortable. For example, I had a hearing impaired practicum student in my classroom who brought his captionist with him to class. I read this article during the time period that they were in my classroom and thought I would try Koenig’s suggestion and really wait those three to five seconds. During my experiment with Koenig’s suggested wait time, the practicum student’s captionist came to me one day after class and said, “I felt some tension in the room today. It was really uncomfortable for me.” I didn’t tell her what I was trying to do, just that I was pushing the kids more. She may have walked away thinking that I was being too hard on them. After providing the three to five second wait time for several days, the students were attempting to disagree with each other more on an academic level, and, in turn, there was more effective discussion.

The next question, though, is how do we, as educators, get the students engaged and willing to participate?

Student Attitude and Involvement:

One approach that was suggested in the readings is to be non-direct with the students so that they offer information but feel less intimidated. “Some less direct

approaches include non-leading questions that respond to student ideas, paraphrasing a student's answer to help him/her look more carefully at what was just said, and the use of wait time" (Koenig, 2001, p. 9). Using these techniques can help to bring the more inhibited student into the conversation. After all, involving a majority of the class is very important. Koenig (2001) states that we, as teachers, are responsible for helping students pursue challenging mathematics by being able to read our students' abilities and readiness well. It is vital that we introduce concepts to student at their readiness level. It is a challenge to build a student's confidence and get them involved in math for which they are not ready. It is more appropriate for a teacher to be able to "read" a class's needs than for the students to have to tell the teacher the skills and concepts in which they are lacking.

Grouws and Lembke discuss motivational factors for students learning mathematics. They determine that true motivation is intrinsic and not for the purpose of completing a task or being better than someone else. Grouws and Lembke (1998) assert that "a teacher must be aware of and sensitive to the needs of her students or she is in danger of assuming a teaching style that satisfies her own needs instead of the motivational needs of her students" (p. 249). This assertion is completely reasonable. As an educator it is easy to fall into whatever teaching style is comfortable and not necessarily what the students need. When this happens, the teacher in question runs the risk of having the students "unplug" themselves from the class or become frustrated with the lesson. Teaching to the learning style of the students will certainly increase motivation in the mathematics classroom discussion.

One noteworthy technique is the "pass the pen" technique, which is intended to involve every student in the discussion. The teacher writes a multi-step equation on the

board and then hands a student the marker. As the selected student completes that step, he or she is also required to explain his or her thinking as they work the equation. The student then calls on the next student, gives him the pen, and then that student figures out and explains the next step. If a question comes up, the student holding the pen can answer it, call on someone for help, or pass the pen to a different student. Clearly this process will take more time than a *teacher* completing the necessary steps for the class, but the process forces students to think about and reflect on their work (Hawes 2006).

Hawes (2006) studied students using different activities to teach error analysis to learn from their mistakes. She determined that error analysis helps students to become more accurate in their mathematics. She also says that they are more able to work cooperatively to correct their homework. Hawes also discusses the amount of classroom structure necessary for constructive discussions. The underlying need for classroom structure supports the premise that the students don't have to figure it out for themselves; they do not have to be on their own and unmanaged for the concept to make a difference. As a matter of fact, the teacher must be involved to help motivate his or her students; there is a precarious balance between teacher control and too many student choices, and each teacher has to find that balance.

This concept was illustrated one time when I did a lesson/activity with my algebra class that involved the relationship of the slopes of parallel lines. They knew that the slopes had to be the same, so I assumed that they would be able to find the relationship between the slopes of perpendicular lines. I had my graph paper, rulers, and colored pencils all lined up and ready to be handed out. I was excited to see what they would come up with during the activity. The end result was a mad house; by the end of the activity, some groups were throwing things, some were talking about social topics, and

most were completely off task. Those groups that did try to make an attempt were frustrated with me. Part of their homework was to reflect on why it had gone so badly; over and over students wrote that they didn't know what to do, didn't have enough information, and that they wished I would have given them more direction.

This research project differs from the published literature in several ways. For instance, published research involved ways in which one applies discussion in the classroom while this research concentrates more on structuring discussion in the classroom. Also, while this research investigates the benefits of structured discussion, most published research investigated the benefits of the components of mathematical discourse.

Purpose Statement

The purpose of this project was to learn how to structure a classroom so that the students can be enriched by and learn from constructive mathematical communication. Additionally, the development of an effective method for both student and teacher to help in the discussion process was desired. I wanted to understand the influence that mathematical discussion would have in my classroom; it was my intent to have a student driven discussion having myself acting as facilitator and guide. My research questions were 1) how does a teacher facilitate mathematical discourse in the classroom and 2) how are students best "trained" to have an effective discussion about mathematics?

Methods

When I began planning this study, I was not sure how to go about *measuring* students' interest in mathematics as a result of their classroom discussion. I knew that I needed to first get them talking. That was not difficult. What I found to be a challenge was that they would not necessarily talk about math. That was when I decided to add

some structure and purpose to their discussion. I created packets (Appendix A) that not only helped them with their discussion but also helped me to determine the students' level of interest and learning. I decided to gather data in three ways: I kept a journal when students discussed, I collected two sets of packets from the students, and I also collected a student survey regarding the packets.

I decided to keep a weekly journal because of the feelings I was having as I watched students discuss using the packets I had created. I wanted to keep a record of those thoughts because I thought that later on, as I began to compile the data, I would have lost exactly what I was thinking and when I had thought it. The dates I had journal entries for were Fridays: April 27, May 4, 11, 18, and 25, 2007.

I also determined that surveying students would give me invaluable insight into what they were thinking in terms of their level of interest, frustration (if any), how the packet(s) was working for them, and if they felt they were learning from it. (Appendix B). I surveyed the students on June 6, 2007. The reality of their reaction was more powerful to hear from them than if I had made assumptions about their thoughts.

Lastly, collecting their packets was important because it gave me an idea of how they were learning. I collected the packets on April 11 and May 23. I could depend on the students to tell me about their perception of the discussions. I could not, however, ask them to explain in a way that would be helpful to me in this study how their work had changed. I had to see it for myself. I also wanted to keep a record of how I graded their packets; the rubric I had used was attached to each individual's packet.

As my data collection relates to both my research question, "How does a teacher facilitate mathematical discourse in the classroom?" and "How are students best "trained" to have an effective discussion about mathematics?" I chose my own journal entries,

student surveys, and student packets as a way to determine both how a teacher would facilitate the discussion as well as how the students best learn to discuss.

I organized the data by looking at my weekly journaling to see where the data was headed. I separated the first "draft" packets the students used from the second "improved" packets. I had expectations in terms of how the students expressed their thoughts while solving these problems and categorized the differences among the two packets. I also categorized the responses the students gave in the survey. I found "similar key phrases" students wrote about and grouped those responses. I analyzed the data by assessing the effectiveness of the packet I put in place for the students to use during discussions. I also evaluated the responses the students had to my survey regarding the use of the packets.

Findings

For my first research question, "how does a teacher facilitate mathematical discourse in the classroom?" I asserted that creating a structure for students to follow will allow teachers to facilitate mathematical discourse in the classroom. This assertion proved accurate. In my journal on May 30 I stated, "The students had no interest in the locker problem. They were frustrated with me because I was making it seem as though they should just work it through." I knew at the time the reason they were frustrated was because they had no direction and no purpose. I felt that they needed more structure. In the students' own words, they respond in a survey stating, "I really liked being able to talk about the problem and really understand it! It also let me think of different ways of doing the math problem."

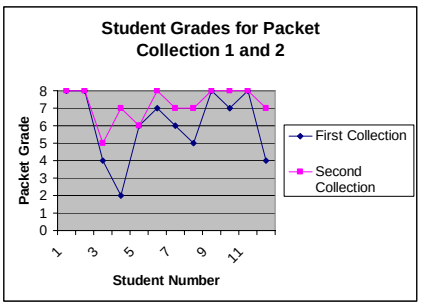
In my journal on May 25th I said, "Class was more focused today. They got through their packet roles in a timely manner and were able to work practice problems

together." It was really nice to see how the students had grown from a frustrated problem solving mess to a group of students that could anticipate their part in class discussion. They were then able to offer something they had confidence in rather than being put on the spot and telling the class, "I don't know." Another student wrote on the survey, "You can see if anyone got it and where you messed up and you ask questions and you can teach your peers." This sentiment was the essence of that which I had hoped to see as a result of the processes implemented. I was so pleased to see this response. I knew that when I began this project, gave them a problem and told them to attempt it without any direction, they would certainly not get then what that student got out of it at the end.

Other evidence that supports my assertion is the way students completed the roles in their packets. Each small group was assigned a role they were responsible for in completing the problem. I really wanted students to not only attempt the problems but to attempt them using methods we had talked about previously. I knew that if I had given them incomplete directions and asked them to just solve a problem they would not necessarily utilize the methods. However, I structured the packet so that students would be directed toward the use of those roles. For example, I wanted students to restate the problem using words they could understand. I developed a role named "the summarizer," and their job was to rewrite what the problem was expecting, but in the group's own words. A student wrote as a response to a word problem, "For # 2 I am to write the problem in standard form. To do this I must arrange it by greatest exponent." Another student wrote, "It is like a football team. You want the bigger players up front." These students stated the same idea in very different ways. However, both show good understanding of standard form. The idea is that the student brings this thinking to the

table for the next day's discussion. Others will hear how they have thought through the problem.

For the research question, "How are students best "trained" to have an effective discussion about mathematics?" I made the assertion that giving the students consistent and thorough feedback after they have had their discussion will best help to "train" students to have effective discussion. I prepared a rubric to use when grading the packets (Appendix C). Additionally, I offered a rubric (Appendix B) that would allow the students to grade each other on group participation. The teacher rubric I made told the students how well they covered the expectations of their role in the discussion and how well their mathematical ideas were represented in their discussion packet. The peer rubric measured such group work aspects as working well with others, staying on task, offering well-thought ideas, attitude, and preparedness. Student work and participation greatly improved from the first packet collection to the second packet collection. In order to maintain student confidentiality, I only analyzed data from 12 of the 15 students who consented to participate in this study. The 12 students were randomly selected by the teacher who had the consent forms, and their names were removed from the packets I analyzed. From the first collection, 5 of the 12 earned a 5 out of 8 points or below. I used the same sample of students from the second collection and of the 12 students, only 1 earned below 5 of the 8 points offered.



The graph of packet grades clearly shows an improvement from the first packet collection to the second packet collection. Either students' grades remained strong or there was an improvement. I believe the reason for this improvement was that the students worked really hard to make their peer grade better and show their mathematical thinking more. I also believe that students were getting used to the packets themselves and that was part of the reason their grades improved. Therefore, I cannot attribute the increase in grades solely to the feedback from the rubrics.

Conclusion

My findings tell me that having discussions in the mathematics classroom is very important and effective. My data shows that students appreciate the discussion and get a lot out of it. It also shows that in order to have more effective and meaningful discussion the teacher has to provide structure and purpose to the discussion. Simply asking students to "talk" about a topic is not enough. It is imperative that the teacher lead students into meaningful discussion. The trick is to let them lead the discussion.

My findings also show that it is important to provide students feedback about their discussion. It is not enough to listen to their discussion. The teacher must provide feedback in order for the students to learn how to effectively discuss with one another. It is necessary for the teacher to provide positive feedback about the discussion methods that he or she would like to see used again in the future. Highlighting a student's mistakes may keep them from sharing in the future.

Implications

I will most definitely continue the practice of having students be heard in my classroom. I understand that I must make some of the expectations in my discussion packet more clear, however. The packets made sense in terms of getting students to have

a structured discussion and guiding them to cover all of the points I felt necessary. There were some roles which could be tailored more toward the expectations I had. For example, I wanted students to state a strategy they might try to solve the problem at hand. I titled this role the “summarizer.” I found that students simply summarized what the book stated in their own words. I thought that maybe I would change this role title to “strategist” and that this new title would get students to not only restate the problem in their own words, but to provide a strategy for the problem as well.

I did find that this process was difficult to introduce two-thirds of the way through the year. In the future, I will be sure to introduce this technique to students at the beginning of the year. It will be part of my classroom. I will present it in a positive manner. A packet problem will be assigned along with practice homework. Of course, the practice homework will be to sharpen the new skill they have learned, and the packet question will be for purposes of discussion.

Finally, I will better structure *how* the group spends their time. In my study, I found that structuring the discussion itself was important, but it is also helpful to get students accustomed to using their time wisely by giving them an agenda. For example, when the students have completed going through the roles of the packet for the discussion problem, and they have time left over, they can do a few examples with their peers and write a short reflection about how they are doing with this skill.

I would advise that other teachers with a similar problem of practice spend time establishing a way to make discussions structured in their classrooms. It is important for the discussions to be structured in order for the students to get the most from them. It is also important that the teacher make this work for them in their classroom. What may have been successful in my classroom may not be in another.

If a teacher thinks there is little time for discussion yet is considering adding it to his or her class period, I would advise them to create an efficient timeline that students are to follow. The more specific the expectations, the more efficient students will be. If students are given directions that are consistent and thorough, they will be more independent and use their time more wisely. A suggestion is to have the teacher use an overhead timer and lay out the goals student should strive to reach in the given time period. It is also helpful for the teacher to be prepared by knowing the discussion topic well. If the teacher is organized with notes about what they want the discussion to touch upon, then the students are more likely to stay on topic.

I would strongly urge math teachers to look for the value in classroom discussions. It is quite obvious that we discuss in other classes so we can show that we value our students' observations and opinions. There is no reason it should be different in math. I believe that sharing my thoughts on streamlining discussions in math with other teachers in a Professional Learning Community setting would prove effective.

I really found the classroom discussion packet to be an exceptional tool in my classroom, and I will continue to make improvements on the packet and use it in my class.

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Appendix A

Algebra Name _____

Math Discussion Groups Date _____

Group Discussion Roles **Due Date:**

1. Strategist (leadership) _____
2. Questioner _____
3. Dissector _____
4. Visualizer _____

If you are in a group of 3, the visualizer will also take on the role of the dissector.

What will Mrs. Fricke be looking for?

- Groups who are prepared with appropriate materials.
- Members that are focused on each other and the discussion.
- Equal participation with exemplary manners.
- Eyes on the person speaking.
- One person speaking at a time.
- Use of appropriate voice level for group work.

There will be approximately 10 minutes of group time.

In your 10 minutes of group time you should:

- Go through each role one at a time.
- Make necessary revisions to your write up.
- Work assigned practice problems.

Strategist

Page: _____

Problem #: _____

Your job is to describe your "plan of attack" when working this problem. Don't forget to include when you took the approach you did. (It is not necessary for you describe how you worked the problem step-by-step)

Strategy:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Questioner

Page: _____

Problem #: _____

Your job is to write down questions you have about the problem.

Suggestions:
What did you have to consider while working this problem?
What skills were required to complete this problem?
What did the problem remind you of?
Where could potential errors have been made?
Were there any difficulties/frustrations?
You will also answer each question with complete sentences. Support your answer with details from the problem. **You must ultimately answer.**

First Question:

_____

_____

Answer:

_____

_____

_____

Second Question:

_____

_____

Answer:

_____

_____

Dissector

Page: _____

Problem #: _____

Your job is to show your **mathematical** work step-by-step **for each problem in its entirety.** You want to show your group members what the problem should look like if all of the math work were shown. It is to be written like a final draft. It is to be clear and precise. Do not question *how* you arrived at a solution. You may use a different method than the others and that is okay.

Steps:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Visualizer

Page: _____

Problem #: _____

Mathematicians make pictures in their mind as they work. Your job is to record your mental image of a significant part of the assigned problem.

Use graph paper, charts, technology such as computers or calculators, colored pencils, rulers, etc., to sketch a drawing of your mental image. What do you see?

Appendix B

Your Name:	**Team Member Names**			
Score: **1=Poor 3=Great**				
Worked Hard				
Worked well with group				
Stayed on task				
Offered good ideas				
Positive attitude				
Was prepared				
Good work quality				
TOTAL:				

Additional Comments:

Appendix C

CATEGORY	**4**	**3**	**2**	**1**
Role	4 roles were completed thoroughly.	3 roles were completed thoroughly OR 4 roles were completed.	2 roles were completed thoroughly OR 2-3 roles were completed.	1 role was completed thoroughly OR Student shows little understanding of overall concept.
Math	Answers correct for all 4 problems. All math work shown for all 4 problems.	Math work shown for all 4 problems. OR Answers correct for 3 problems. All math work shown for 3 problems.	Math work shown for 2-3 problems. OR Answers correct for 2 problems. All math work shown for 2 problems.	Math work shown for 1 problem. OR Answers correct for 2 problems. All math work shown for 2 problems.