7-1-2007

The Effects Improving Student Discourse Has on Learning 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
July 2007

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Abstract

In this action research study of my 8th grade mathematics classroom, I investigated how improving student discourse affects learning mathematics. I conducted this study because I wanted to give students more opportunities to develop and share their ideas with their peers as well as with me. My idea was to create a learning environment that encouraged students to voice their opinions. In order to do so, I needed to reassure and model with my students that they were in a classroom where it was safe to take risks, and they should feel comfortable sharing their ideas. By facilitating activities for students to complete in groups, asking students to prepare work to share with the class, and offering more opportunities for students to work with each other on discovering and exploring math skills being presented, I set the tone for abundant student discourse to take place in the mathematics classroom. I discovered that students became more comfortable with math skills the more opportunities they had to discuss the ideas in various settings. I also found that as the study went on, students discovered the importance of being able to share their mathematical ideas and valued the ability to verbalize their thoughts with others. As a result of this study, I plan to continue offering many opportunities for students to work in groups as well as to share their ideas with the class.

The topic of my study is student discourse. I am interested in helping students improve their ability to verbalize their mathematical ideas. Traditionally mathematics instruction includes a lot of teacher discourse and paper-pencil work by the students. As a teacher of 8th grade mathematics I want to offer my students more opportunities to be active participants in the learning that is taking place. I think it is important for students to be able to show their math ideas on paper as well as to be able to appropriately express their mathematical ideas verbally. Along with this idea is the importance of being able to listen to others, understand the language and vocabulary, and be able to participate in a meaningful conversation about math.

I selected improving student discourse as my topic because I have been in large classrooms where only selected students have voiced their mathematical ideas. I think many math classrooms operate in this manner, not at the fault of the teacher, but rather this is just the nature of middle school students. There always seems to be a handful of students who have no reservations about verbalizing solutions or questions, but the majority of the class remains silent. However as a teacher I want to hear from all of my students. I know that each young person has a different comfort level and ability to verbalize their ideas. I have made it my goal to set the tone in my classroom for all students to have the opportunity and ability to share their ideas.

Problem Statement

Improving student discourse is a topic worth knowing because many teachers, including me, are challenged to find different ways for students to communicate their ideas. I think it is reasonable to have some level of expectation for students to be able to read, write, and talk about mathematics. However, when it comes to verbal communication I find it difficult to engage all students in the learning process.

All math teachers should care about this problem because educators are given

expectations by schools, districts, and the National Council for Teachers of Mathematics to engage all students in learning. The NCTM's (2000) *Principles and Standards for School Mathematics* has a processing standard that highlights communication. The description under "Communication" states that students should be able to organize and consolidate their mathematical thinking through communication. NCTM also suggests that students should be able to use the language of mathematics to communicate their mathematical thinking coherently and clearly to peers, teachers, and others. These ideas have guided me to choose student discourse as a topic to study with the anticipation of improving students' experience learning mathematics.

Literature Review

Traditionally, the discourse that takes place in a mathematics classroom has generally been dominated by the teacher. The language typically offered by the teacher has focused on the rules and presentation of skills necessary for students to learn a particular objective. More recently there has been a shift in focus to allow more student conversation and inquiry to take place during the course of a lesson.

Personally I am interested in engaging students in more meaningful, inquiry-based discussions, with the anticipation of increased student learning. Additionally I would like to establish a learning environment that encourages all members of the class to become active participants in the conversations of focus. Investigating if improved student discourse enhances student learning of mathematics has lead me to review many writings of various authors, all of whom have valuable and insightful information on the topic.

A primary theme that I discovered as I reviewed different studies was the link between oral communication and written communication. I understand how the nature of these two types

of communication support each other, but I was quite surprised at the vast amount of research that focused on using both strategies to improve learning mathematics. I believe this connection stems from the standards set by The National Council of Teachers of Mathematics (NCTM), which stresses the ability for students to communicate mathematics in various ways, specifically written and oral. In the report "Using Oral and Witten Language to Increase Understanding of Math Concepts," Fortescue (1994) discusses her approach to improving student communication. Fortescue's research included collecting samples of student work, journaling, and observations of group modeling. Through her work, Fortescue determined that students are able to practice mathematics in a meaningful way when increasing student discourse in the classroom. In return, students also improved their ability to write their mathematical ideas to communicate with others.

I began by incorporating new instructional strategies to develop students' abilities to write about math. I recalled the importance the NCTM placed not only on writing but also on mathematics as *communication* as a whole, including discussion, reading, writing, and listening to mathematics. Therefore, I spent much more time on whole group modeling of both oral language and written language. I also asked the students to communicate a message to each other and to me that would be meaningful. We did this through oral discussion in which students could 'talk mathematics.' These discussions were followed by writing and oral reading (p.576).

Additional literature I read led to the idea that increasing the students' opportunities to write their mathematical ideas in effect would also improve students' ability to effectively communicate verbally. I have found that in most of my math classes it is rare for a student to have dual strengths in both their written mathematical communication and in their oral communication. I want to focus on increasing student learning through improved student

discourse, and I believe that some written communication may be involved in that process.

While I still want to emphasize improving student oral communication, I found an author who discovered that incorporating small pieces of writing prior to group discussions can add depth to the conversations in which students participate. Johanning (1999) explained how her study emphasized writing as a way to aid students in learning to think and talk mathematically. Johanning points out that traditionally student writing has been a source of communication between student and teacher. Johanning created her study to determine if writing could be a preparation for students to take part in a discussion with the teacher, peers, or the entire class. After examining her sources of data (participant observations, student interviews, audio taping of students working in groups, and examining written work), Johanning concluded that "rich learning experiences are possible when writing is used as a way to prepare students for group discussions in mathematics" (p. 151).

Baxter (2005) conducted a similar year-long study and concluded that allowing time for students to journal in class revealed a lot more mathematical ideas than what was offered during class discussions.

> Our analysis of the students' journals identified multiple instances where the students were able to explain their mathematical reasoning, revealing their conceptual understanding, ability to explain, and skill at representing a problem... The promise of writing is that it offers an alternative to the visions of classroom communication that are strictly oral in nature (p.119).

I think Baxter's ideas are valuable, but I found the most compelling testimony for how discourse can improve mathematical thinking came from the students interviewed in Johanning's research. Prior to working in small groups, students were asked to think about a problem or skill and independently attempt a problem solving strategy and possible solution. Students knew the expectations that the teacher held for them, which included being ready to contribute to a

group discussion.

I think the pre-writing activity gave the students the time to think independently about the problem and form their own opinions or strategies. Then when the group convened, whether it was a small student group or an entire class, the students had the opportunity to become comfortable with the problem or skill and formed the ideas that they felt were important to share with the group. Of the group of students that participated in this study, over half reported that being able to share written work with a group increased their understanding of the math problems. Students in the class used many different approaches to solve the same problem. After viewing each others' ideas, students indicated that they might like to use another student's idea if given the chance to try the problem again. One of my students proclaimed, "I would not have thought of that in a million years!" Additionally students found that listening to their classmates was often just as helpful if not more helpful as listening to the teacher's explanation.

Another theme evident in the research I viewed was how working together as a class and involving all of the students in discussions can improve the students' ability to put ideas on paper, work through math problems from start to finish, and become more confident of their own mathematical abilities. Anderson and Little (2004) share research findings in "On the Write Path: Improving Communication in an Elementary Mathematics Classroom."

Using data from survey responses, problem solving scales, and rubrics, Anderson and Little found that as they continued to make efforts to involve the entire class in generating the ideas of a lesson that student writing and mathematical verbal presentation improved. I believe that as teachers we can be strong leaders and gentle guides. I think that as a teacher it is important to be the person to trigger the students' mathematical thinking but then let them be the persons working towards a discovery. As a teacher I want to be able to guide, prompt, and

redirect ideas when necessary. Anderson and Little felt that an effect of offering more time for student discussion was that students were able to better develop their own ideas and use the ideas of offered by their peers. This team of researchers felt that this work lead to making the mathematics more personal for the students and, in effect, more meaningful.

Finally, I believe an important component of building quality student discourse in mathematics is the ability of the teacher to pose questions that spark student interest and thought. In my search for research studies, I came upon the report "Teachers' Use of Questions in Eight-Grade Mathematics Classrooms in Germany, Japan, and the United States," compiled by Kawanaka and Stigler (2000). The main question posed was whether or not certain characteristics of student discourse are positive or negative for student learning.

The investigation involved two different studies. One focused on how much teachers and students talk and what is said, while the second study focused on the use of higher order questioning. The study and results were very in-depth and lengthy. Summarizing the results, all three countries that participated in the study had similar outcomes in that the teachers dominated most of the classroom talk and most often the students' opportunities to talk were provided when teachers questioned them. Due to the language and teaching differences of the three countries it was difficult for the study to conclude if higher order questioning or increased student talk would benefit student learning

This research project differs from the published literature that I explored in several ways. For instance, this research involved middle school students, specifically eighth graders. Most of the literature I read focused on students in elementary classrooms. Also, while this research investigates student discourse and verbal communication, much of the published research that I viewed investigated communicating mathematics with writing. Additionally, the few research

pieces that did concentrate on verbal communication focused on collaborative groups. My research project extends student discourse beyond what occurs in small groups and also encompasses the discourse that occurs in general classroom discussions.

Purpose Statement

Through this project, as I work to improve student participation and discourse in math class, I also have the vision of strengthening the community of learners I have in all of my classes. I think that it is important to create a positive environment that is conducive to students feeling comfortable in opening up their communication avenues and possibly taking risks with their mathematical ideas. In effect, I hope these efforts will strengthen my students' courage, and they will become active participants in mathematical discussions. I believe that once students have overcome the fears of sharing their ideas (right or wrong) with each other, the class, and the teacher, then a whole world of opportunity for in-depth learning will emerge. I want my students to feel like they can learn from each other and with each other. I want my students to view me as a guide and as a participant in the learning process. Most importantly I want my students to feel like they are able to make valuable contributions to their mathematical learning environment and feel comfortable and confident in their mathematical abilities.

The purpose of this study is to determine if improving student discourse in middle level mathematics will enhance student learning. As a middle level math teacher I will work to teach, model, and encourage good communication skills in the math classroom. If students are able to properly convey their mathematical ideas with the teacher as well as their classmates, then the mathematics being studied can be discussed with greater detail and accuracy. In addition to mathematical ideas being expressed appropriately, discussions that take place during the class will be of a higher quality, with more students contributing. This research project will study the

effects that improved student discourse has on student learning, student expression, and student participation in mathematics class and asks the following questions: 1) In what ways do students see a connection between verbal communication in math class and their understanding of mathematical ideas? 2) What will be the effect of dialogue on students' mathematical ideas and knowledge? 3) What impact will opportunities to participate in discourse have on students' willingness to participate?

Method

To pursue the study of student discourse in my classroom, I used several different methods of collecting data; I collected data during the spring semester, 2007. I started my study by asking my students to complete a 10-question survey (see Appendix A). This particular survey asked students to answer questions about their personal beliefs and opinions pertaining to learning mathematics. I chose to use this survey because it would give me an idea whether students valued the ability to share their math ideas with the class. Also, this survey was to detect students' comfort level when participating verbally in class. I recorded their reactions at the beginning of my study in February, before implementing various opportunities for verbal communication and interactions, then again three months later at the end of my study in May.

I organized the results of this survey by totaling the number of students that chose each response. Then I found the percentage that each response received based on the total number of students that participated in the survey. In February, 20 students completed the survey. In May, 21 students completed the survey. I analyzed the data by comparing the results from the February data with the results from the May data. My data is represented in two stacked bar graphs (see Appendix B).

Another method of data collection that I used was a student rubric (see Appendix C). I

gave the students a rubric to complete on three different times during the study. On one occasion during each of the months March, April, and May, students scored themselves using a scale of 1 to 3. There were five categories on the rubric for students to consider: participation, vocabulary, comfort level, learning, and understanding.

I chose to administer the rubrics after a variety of activities. I wanted students to experience sharing ideas and communicating with each other in different settings, then give me their feedback after each diverse activity. This allowed me to see if the type of activity and setting it was completed in influenced how students felt about collaborating. In March the rubric was used after students worked in small groups on an in-depth "Area and Perimeter" investigation. In April students completed the rubric after working through several practice problems from a particularly challenging lesson on simplifying radical expressions. In May the rubric was completed after small groups collaborated on a chapter review.

I organized student responses from each set of rubrics by finding the percentage of students who selected 1, 2, or 3 points for each of the five categories. Of the hundreds of responses generated, the 1-point score was used on only 4 occasions. This prompted me to disregard this section of the rubric and focus on the 2 and 3-point responses for each category. I displayed the data in a bar graph (see Appendix D).

The third method of data collection that I used came in the form of interviewing a small group of students. I asked the class for volunteers to participate in a student focus group. Five students agreed to meet with me once in February and again in May. We met briefly during class, and I asked the group five questions (see Appendix E). Students volunteered their responses and some students spoke more than others. I recorded responses and parts of the discussion in my journal.

I chose to use this form of data collection so I could expand on some of the ideas I was trying to detect in the paper forms of data collection. The student focus group gave me a chance to hear the students voice their feelings and opinions in a conversation with me. The pre-designed response forms were a great way for me to collect and analyze data. The focus group made the study more personal. Some of the information I collected during these two sessions is used as student quotes in the "Findings" section of this paper.

Finally, I kept a personal journal. I kept the journal from February 15, 2007 to May 1, 2007. I wrote about one entry per week. My entries focused on my observations as students worked in their groups and had opportunities to show work at the board. I recorded various comments that I heard from students as well as descriptions of behaviors I saw and mathematical language I heard from students.

Findings

The first research question that I wanted my study to address was, "How do students feel that verbal communication will help them understand mathematical ideas?" I started my study on the basis that many of my 8th graders spent more time in former math classes listening to instruction and less time talking through problems and skills. During the first meeting of my student focus group the topic arose about the amount of time students spent sharing and verbalizing ideas in groups, pairs, and with the entire class. One student replied, "We did some work in small groups in my 6th grade class but less in my 7th grade math class. I think it depends on the teacher." I agree with this student; it does depend on the teacher's style of instruction as to how skills are taught and how students learn.

The purpose of my study was to create more opportunities for kids to interact with each other, me, and the class. In return I wanted students to find that collaborating and sharing can

add value and meaning to the math skills being taught. Based on the data that I collected, I assert that when students are given more opportunities to discuss their ideas and are encouraged to share mathematical thoughts, they gain appreciation for being able to verbalize their ideas.

This assertion is evident in the data that I collected from the student belief survey. In February when asked to respond to the statement, "I think it is important to be able to verbally communicate math ideas with others," 20% of the students responded by saying they strongly agreed. After three months of being given many opportunities to talk about math, students were asked to respond to the same question. This time 43% of the students said they strongly agreed, an increase of 23%.

As students moved through the study with me, they were asked to complete rubrics after various activities. One of the categories on the rubric was "Understanding." Students were asked if participating in the discussion helped them understand the subject more. The scale was from 1 to 3. The following percentages give the number of students who chose a score of 3 when asked to respond to "I think being a part of today's discussion really helped me understand the subject more": March 73%, April 86%, and May 96%. This data shows that as the students experienced more and more opportunities to participate in mathematical discourse they increasingly valued the understanding they gained from the discussions.

The second research question that my study addressed was "Will the use of dialogue assist the students in strengthening their mathematical ideas and knowledge?" Based on my data I assert that when students are given opportunities to discuss their ideas with others, their mathematical understanding will increase. As an 8th grade mathematics teacher, I don't question the idea that students benefit from independent learning opportunities. I designed my study to see if additional discussions, interactions, and sharing thoughts with the class would enhance a

students' mathematical understanding.

Looking at the data I collected from the student belief survey, statement number nine asked students if "Being able to share ideas with others increases my understanding of a topic." In February, 30% of the students responded that they strongly agreed. In May the number increased to 44%.

The data from the student rubric also addressed the amount of learning that takes place when kids participate in mathematical discourse. Students who rated their learning score with a "3" supported the statement, "I think the discussion that took place today really helped me learn more about the subject being taught." In March 78% of the class chose that statement. In April the number rose to 86%, then in May the number reached 92%.

During the May meeting of my student focus group, I asked the question, "How does talking about math and sharing ideas with others help you understand mathematical concepts?" Students responded with statements like, "When I am working in my small group, I like being able to talk about a problem. If I get stuck or forgot how to do something my group can help."

Generally speaking students like the opportunity to work with their peers. They find reassurance in being able to think and talk with others as they work through the math. At the same time students develop a deeper understanding of mathematical concepts when they can use ideas from others to build on and develop their own understanding of a skill.

My final research question addressed students' willingness to participate in discussions. After reviewing my data, I assert that student willingness to participate in a discussion relies more on their comfort level with the material being addressed than it does on the amount of increased student discourse. This finding may be of a surprise to some teachers. One might think that if students are groomed to be involved in mathematical discourse, then they will be willing

to talk about any math topic.

My data revealed that despite the amount of time and exposure students had to improving their discourse, their security with the content outweighed their experience in participating in discussions. Student survey question number 7 stated, “If students are confident in their verbal communication skills then they are more likely to participate in a class discussion.” In February 45% responded by saying they strongly agree. In May when asked the same question, 38% of the students said they strongly agreed. Although the 7% decrease is not largely significant, I think students want to feel confident with both their ability to participate as well as the content being discussed. It is difficult to convince 8th graders to take risks in front of their peers if they are not confident on both fronts--discourse and content.

This idea is echoed in the data that I collected from the student rubrics. Under the categories of participation and comfort, the students who rated themselves with a score of 3-points fluctuated during the three months of the study. The most significant change in 3-point scores occurred under the category of vocabulary and terminology. Students were asked to rate themselves based on the amount of math words and terminology that they used appropriately. In March the students completed the rubric after a lengthy investigation on area and perimeter. I lead the discussion through parts of the investigation, and the students had a lot of exposure to the topic in previous math courses. Thus when they filled out the rubric, 61% of the kids rated their vocabulary use with a score of 3. In April students completed the rubric after attempting some practice problems from a new and difficult lesson. The number of 3-point responses dropped to 53%. Finally in May students completed the rubric after a large chapter review. The vocabulary from the chapter was challenging and included some big words like ‘polynomial’ and ‘extraneous’. Only 28% of the students rated their use of vocabulary with the full 3 points.

Conclusions

After concluding my study I believe that it is worth every teacher's efforts to try to improve the amount of student discourse in the math classroom. I grew up learning math in very traditional classrooms, and I don't think there is anything wrong with the traditional styles of teaching math. However, I also have seen wonderful learning taking place in classrooms taught with more contemporary styles. No matter the style of teaching or the type of mathematics classroom that exists, I believe all students would benefit from improved student discourse. The results of my study and the feedback I got from my students support the notion that it is worth every teacher's time to try to incorporate as much student discourse into the classroom as possible.

I found it remarkable how the quality of the discussions that took place among the students increased as my study progressed. My study was not high-tech or extremely complicated. I merely made the effort to insert into my lessons more opportunities for students to discuss and explore math with their peers. During the initial stages of my study, I often had to prompt student thinking and encourage students to develop their ideas verbally. By the end of my time with the students I heard student conversations that would impress any mathematician. Most importantly increasing student discourse proved to increase my students' understanding of the mathematics being taught.

Implications

As a result of my study I will continue to make efforts to improve student discourse. When I plan my lessons I will always be looking for appropriate places to incorporate opportunities for students to improve their ability to verbalize mathematical ideas. I will physically arrange my classroom and students' desks so that discussions among students can be facilitated easily. I would like to try to convince others to imitate what I have done. I can start with the math teachers in my building. I job-

share with another math teacher. I will be able to show her how I develop student discourse and encourage her to use some of my strategies. Additionally the teachers in my building can use me as a resource if interested in new ways to enhance student learning. The professional learning communities that I participate in will be a suitable venue for sharing my study and results. I can be a guide for others who are interested in working with their students in similar ways that I have explored in this study.

References

Anderson, M.. & Little, D, (2004) On the write path: Improving communication in an elementary mathematics classroom. *Teaching Children Mathematics,* 468-472.

Baxter, J. (2005) Writing in mathematics: An alternative fonn of communication for academically low-achieving students. *Lecirning Disabilities Research* & *Practice,* May 2005, Vol. 20 Issue 2. 20,119-135.

Fortescue. C. (1994) Using oral and written language to increase understanding of math concepts. *Langzrage Arts,* 71, 576-580.

Johanning. D. (2002) An analysis of writing and post writing group collaboration in middle school pre-algebra *School Science and hlnthematics,* 100(3), 15 1-160.

Kawanaka. T. & Stigler, **J.** (1999). Teachers' use of qtiestions in eighth-grade mathematics classrooms in Germany, Japan, and the United States. *Mathematical Thinking* and *Learriing,* 4,255-278.

Appendix A

Student Survey
Completed in February and May 2007

Complete this survey based on your personal beliefs and opinions. Ranging from strongly disagree to strongly agree, circle the statement that best indicates your feelings.

1. I think it is important to be able to verbally communicate math ideas with others.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

2. Being able to explain ideas and reasoning to others is a sign that a person understands the concept or skill.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

3. I am comfortable sharing my mathematical ideas with the entire class.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

4. I am comfortable sharing my mathematical ideas in a small group (2-3 people).

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

5. Being able to appropriately express math ideas is important when trying to learn and understand Algebra.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

6. Using math terminology and vocabulary are important when discussing and sharing ideas.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

7. If students are confident in their verbal communication skills then they are more likely to participate in a class discussion.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

8. I think I learn a lot when I participate in a discussion with other students.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

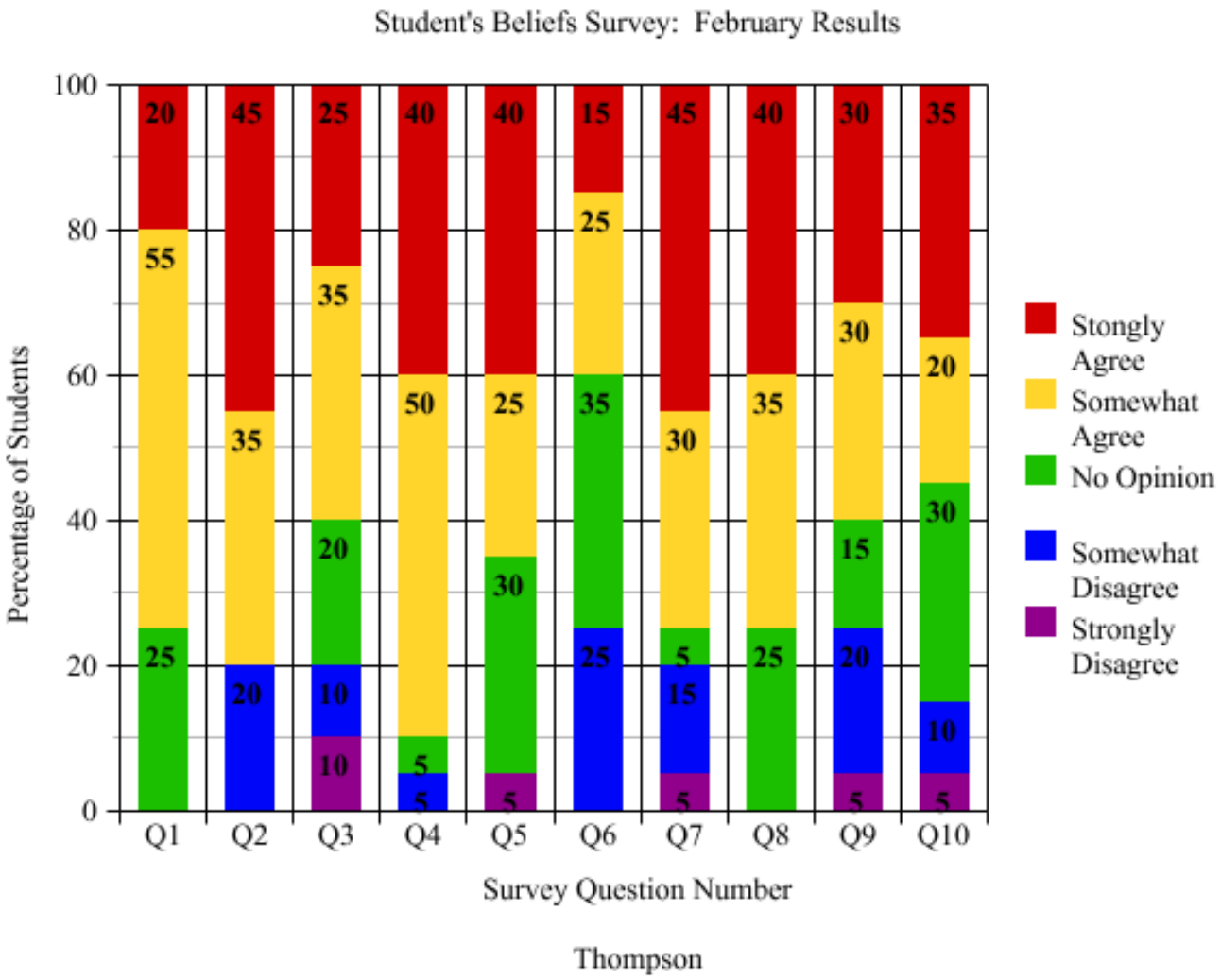
9. Being able to share ideas with others increases my understanding of a topic.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

10. When individuals share math ideas, the whole class benefits and learns.

Strongly Disagree	Somewhat Disagree	No opinion	Somewhat Agree	Strongly Agree

Appendix B



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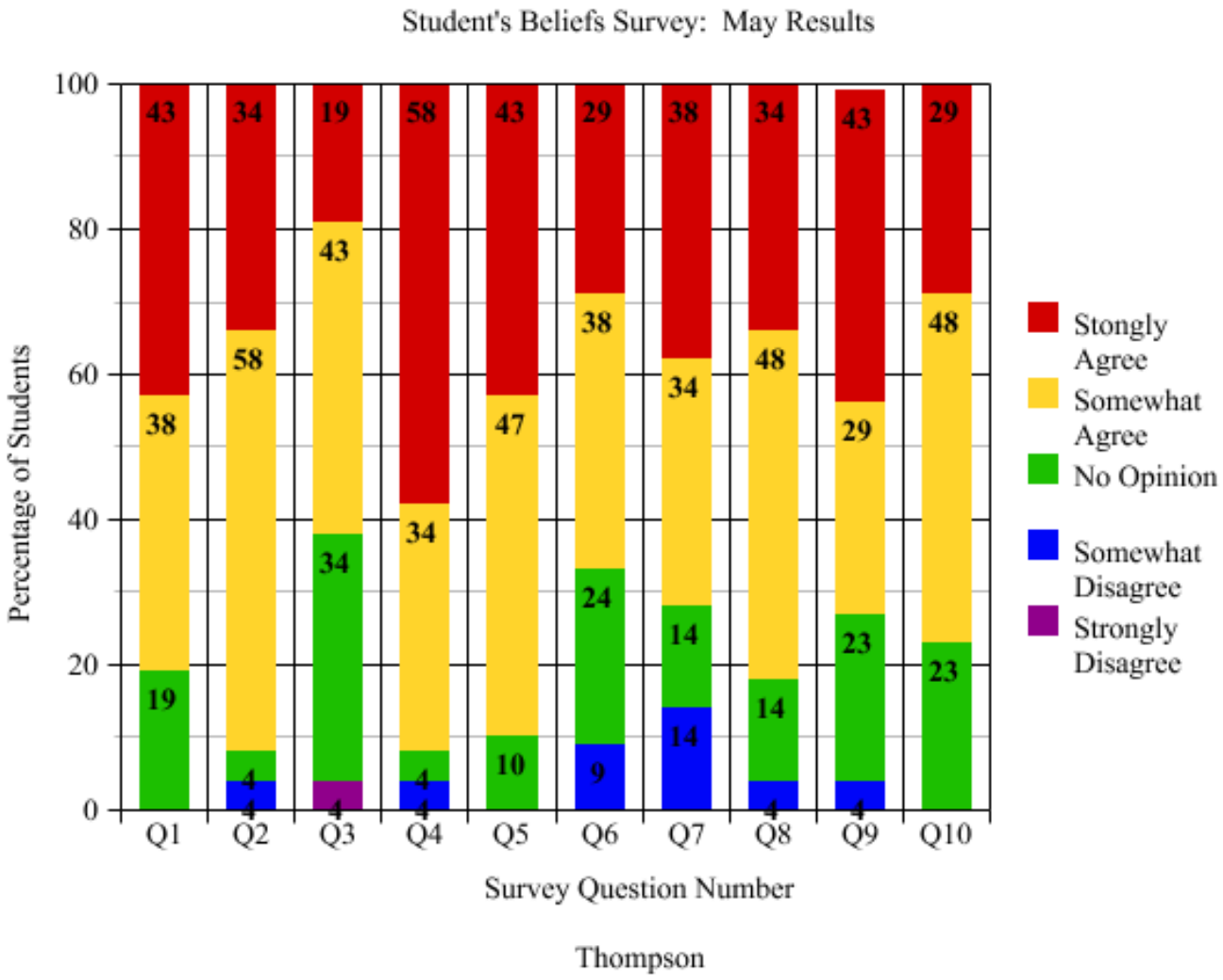

Student's Beliefs Survey: May Results
Percentage of Students
100
80
60
40
20
0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
43
38
19
4
34
58
4
4
19
43
34
4
58
34
4
4
43
47
10
29
38
24
9
38
34
14
14
34
48
14
4
43
29
23
4
29
48
23
Survey Question Number
Stongly Agree
Somewhat Agree
No Opinion
Somewhat Disagree
Strongly Disagree
Thompson

Appendix C

Student Rubric

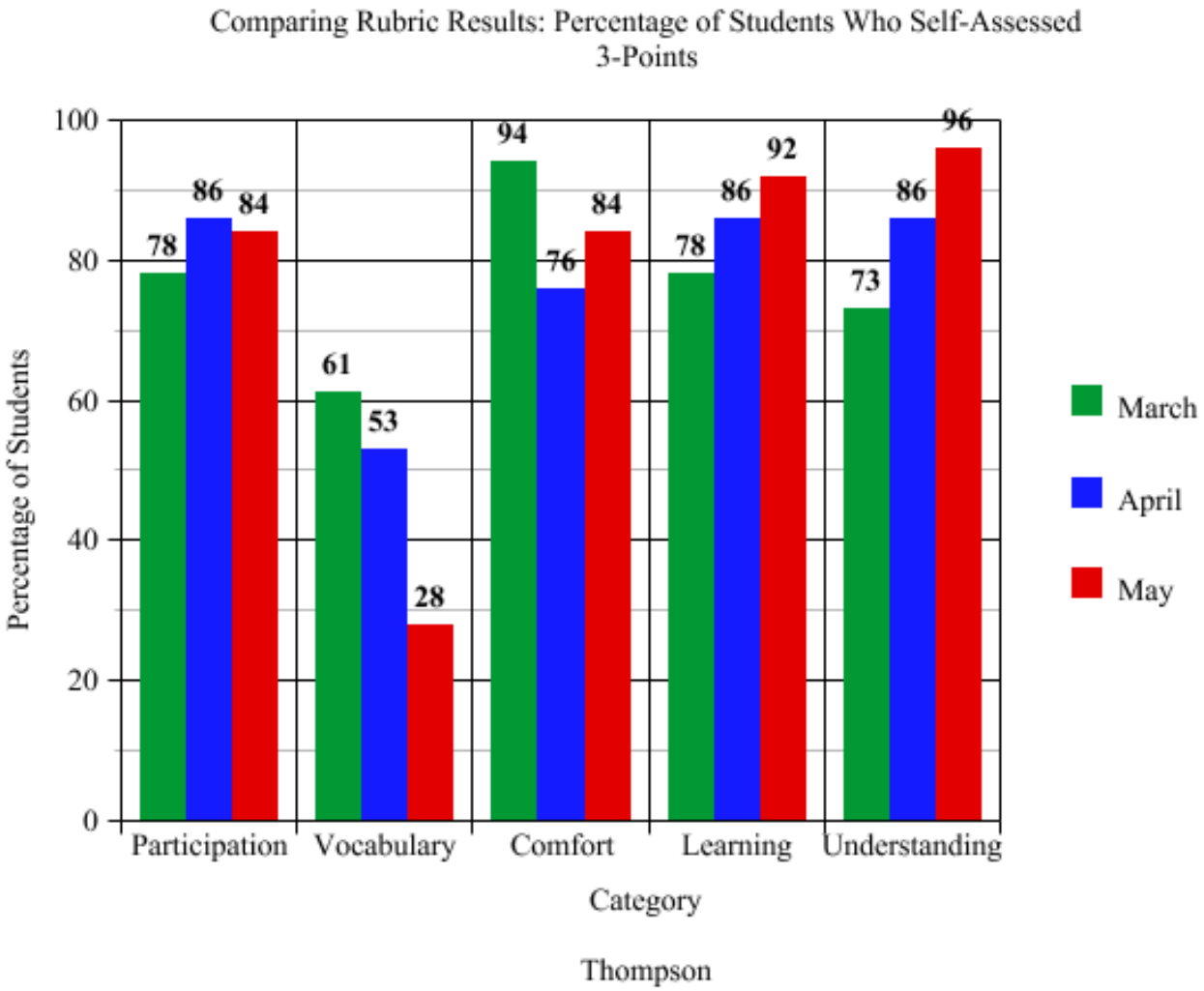
Date:_____ Lesson: _____

Most of today's discussion took place in a (circle one): large group / small group.

Using the criteria provided, rate yourself using a score of 1, 2, or 3 in each of the five categories.

	1 point	2 points	3 points
Participation _____ **score**	• I feel like I didn't participate very much and could have contributed more ideas than what I did.	• I feel like I participated a moderate amount and contributed some ideas to the discussion.	• I feel like I participated a lot and contributed many ideas to the discussion.
Vocabulary & Terminology _____ **score**	• I think that I didn't use very many math words or terminology appropriately.	• I think I used some math words and terminology appropriately.	• I think I used many math words and terminology appropriately.
Comfort _____ **score**	• I didn't feel very comfortable participating in today's lesson/activity.	• I felt somewhat comfortable participating in today's lesson/activity.	• I felt very comfortable participating in today's lesson/activity.
Learning _____ **score**	• I don't think the discussion that took place today really help me learn any more about the subject being studied.	• I think the discussion that took place today sort of helped me learn more about the subject being studied.	• I think the discussion that took place today really helped me learn more about the subject being studied.
Understanding _____ **score**	• I don't think being a part of today's discussion furthered my understanding of the subject.	• I think being a part of today's discussion somewhat helped me understand the subject being studied.	• I think being a part of today's discussion really helped me understand the subject more.

Appendix D


Comparing Rubric Results: Percentage of Students Who Self-Assessed 3-Points
Percentage of Students
100
80
60
40
20
0
78
86
84
61
53
28
94
76
84
78
86
92
73
86
96
Participation
Vocabulary
Comfort
Learning
Understanding
Category
March
April
May
Thompson

Appendix E

Interview Questions
Student Focus Group (5 Students)

Meeting in February and May 2007
(approximately 15-20 minutes)

1. Generally speaking, how do you learn best?

2. In math class, how do you learn best?

3. Do you feel comfortable sharing mathematical ideas and participating in a large class setting (20-30 people)? Do you feel comfortable sharing mathematical ideas and participating in a small group setting (2-3 people)?

4. How does talking about math and sharing ideas with others help you understand mathematical concepts?

5. What characteristics of verbal communication are important when sharing ideas?