Passive or Passionate Participation in Mathematics:

Diagnosing and Improving Student Participation in Mathematics

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Abstract

The purpose of this study was to investigate the reasons behind fifth grade students' participation or non-participation in mathematical discussions, and determine whether this affected their understanding of the learning material. The researcher observed twenty-four students' participation or non-participation in mathematical discussions in a fifth grade classroom over the course of three months. The first half of the study documented student participation or non-participation when the teacher used a lecture-based teaching model. The second half of the study documented student participation or non-participation when the researcher used an inquiry-based teaching model. Quantitative and qualitative data was collected to determine which students participated and in what manners. Assessment results were also collected and evaluated for each of the lessons in the study. The data indicated that all of the students were participating in mathematical discussions for both styles of teaching. The rates of that participation and the nature of the participation were different from student to student, and from lesson to lesson. The inquiry-based method of teaching produced more favorable results in terms of total student participation than did the lecture-based format. The research did not provide sufficient evidence to prove or disprove a definite link between student participation or non-participation in mathematical discussions to student understanding of the learning material. Changes in the nature of student participation were affected by the mode of presentation of the learning material. Additional research is needed to prove or disprove a link between student participation in mathematics to understanding of the learning material. Educators need to apply inquiry-based methods for teaching mathematics in order to change the nature of student participation in mathematical discussions from passive listener to active learner. (Contains 1 table and 12 appendices)

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Introduction

In the course of guest teaching in a fifth grade classroom at a local elementary school, the researcher observed that many of the students did not actively participate during mathematics lessons, and/or discussions. This intriguing phenomenon led to the desire to find out if there was a correlation between participation in mathematics and student learning success, through meaningful discussion and activity. When teaching mathematics lessons, it seemed as though the same students raised their hands to answer questions, while others sat quietly, participating only if called on. The students' unwillingness or reluctance to participate in mathematics was a problem, because they were less likely to find meaning in their learning. The concern was that their understanding of mathematical concepts would be underdeveloped, leading to poor performance in mathematics, and lack of confidence in their mathematical abilities. A critical factor that was suspected to be at the root of the problem was the format in which mathematical material was being presented and discussed. Students were thought to be having difficulty understanding the material when it was presented in a lecture-based format. Other reasons for non-participation in mathematics were also expected to be uncovered during the course of the action research project. The goal of this study was to find the answer to the issue of participation or non-participation, by fifth grade students, in mathematical discussions, and whether or not this had an effect on their learning.

Historically, the study of mathematics in schools has had a negative connotation for some students. The lecture-based approach to teaching mathematics did not address the multiple learning styles of these students. Often, they simply gave up, and held the assumption that they were not competent at mathematics. The foundations of mathematical success begin at the elementary level. As a teacher of mathematics, it was critical that the issue of a lack of active participation by some students was addressed, to determine the cause(s), and make improvements to remedy the situation.

In order to assure that the action research project was valid, accurate, and real, void of any and all biases (video: How Can I Make Sure my Research is Valid?), all prior assumptions related to the research needed to be presented. The researcher believed that using an inquiry-based model for teaching mathematics was more effective than using a lecture-based model. The literature review provided some insight on the subject. All teachers have different philosophies of teaching, and model their teaching practices after different learning theories. Though the inclination to believe that inquiry-based teaching of mathematics will increase student participation and learning success in mathematics existed, the theory could have been completely wrong. "Teacher researchers should...make explicit the things about which they have made judgments, because it is easy to slip into a narrative that seeks to validate one's position (Mills, 2007, p.93). Sometimes a theory is sound, but a teacher may have difficulty applying the new concepts effectively. Initial failure to properly apply an inquiry-based model of teaching could have been attributed to lack of experience by the teacher. Changing one's mode of teaching is a methodical process that takes a great deal of effort, planning, and experience. Therefore, success may be the result of trial and error. All of this was considered when analyzing the results of the action research project. As a teacher of mathematics, it was the goal of the researcher to promote a positive attitude toward mathematics, help students gain confidence in their problem solving abilities, and engage them so that they were actively participating in their learning. Bruning, Schraw, Norby, and Ronning explain that, "being actively involved is essential for meaningful learning, and as students' understanding develops, their perceptions of competence and autonomy both increase" (as cited in Eggen & Kauchak, 2007, p.355). Learning about mathematics should be a positive experience. The lessons should be engaging, and the students should feel safe to participate. The researcher firmly believed that all students could succeed in mathematics, and become involved in the learning process if given the right encouragement and direction. The National Council of Teachers of Mathematics (2000-2004) states that, "students have different abilities, needs, and interests. Yet everyone needs to be able to use mathematics in his or her personal life, in the workplace, and in further study". Active involvement and participation in mathematics is key to achieving this reality. It was also important that the students realized the value of asking questions, and getting involved in the learning process. Finding the cause(s) behind student participation or non-participation in mathematics gave the researcher an avenue in which to help the students gain skills that they would need throughout their lifetime to grow and expand their knowledge.

Area of Focus Statement

The purpose of this study was to investigate the reasons behind fifth grade students' participation or non-participation in mathematical discussions, and determine whether this had an effect on their learning of the material.

Research Questions

1. Which fifth grade students are engaging in mathematical discussions, and in what manner(s)?
2. What effect does participation or non-participation in mathematical discussions have on a fifth grade student's understanding of the learning material?
3. What effect does the presentation of the material by the teacher or discussion format have on a fifth grade student's participation or non-participation in mathematical discussions?

Definition of Variables

Participation in a mathematical discussion included any or all of the following factors. Students who participated raised their hands to answer questions during the mathematics lesson. They asked questions related to the subject matter. They engaged their peers in mathematical discussions and challenged peer or teacher responses in order to gain clarity of the learning material.

Non-participation in a mathematical discussion included any or all of the following factors. Students who failed to participate rarely or never raised their hand to answer or ask questions. They engaged in other activities during the mathematics lesson. They appeared to be bored or day dreaming during a mathematical discussion. These students did not maintain eye contact to show interest in the topic. They sat back during peer discussions and allowed other group members to dictate tasks, offering little or no input.

Mathematical discussions occurred between teacher and student, or student to student. The focus of the discourse was on topics of a mathematical nature. Topics included such things as how to solve a mathematical problem, explanations of how a teacher or student arrived at a particular answer, questioning the validity of a solution or problem solving process, real world applications of mathematics, etc.

The effect that participation had on students' learning was evident in their performances on formative and summative assessments, as well as through surveying students about their participation and understanding of the material. Demonstration of a student's mastery of the learning material, or progression towards that end, was indicative of a positive effect that participation had on a student's understanding of the material. Lack of understanding was indicative of a lack of participation in a mathematical discussion, or there were other underlying factors that needed to be taken into consideration.

Literature Review

Ewing, B.F. (2007). *Participation and non-participation in mathematics classrooms.* Proceedings from Ninth International Conference: The Mathematics Education into the 21st Century Project. Charlotte, NC: UNCC.

The researcher chose this literature, because it supported initial ideas and thoughts about students' participation or non-participation in mathematics discussions affecting their learning success. The author clearly identified that part of the reason behind a student's willingness to participate in mathematical discourse has to do with how that individual views their personal identity in the classroom. This is an aspect to learning that had not been considered. Therefore, lack of participation may not necessarily be tied to a lack of understanding of the subject matter. One practice that was applied to the active research study was gathering feedback from the students in their own words. The students' personal reflections on their participation in mathematics offered insight to their perceptions about mathematics.

The premise of the paper explains how “critical discourse theory enables an exploration in greater depth of the discourses and discursive mechanisms traced in students’ accounts of their learning experiences” (Ewing, 2007, p.182). The author explains, “discourse, discursive practice, and subject position, have been linked to identity, participation and non-participation in classrooms” (p.181). Reading through the explanations of these terms provided in the paper, brought about the understanding that students' participation or non-participation is related to the social structure of the classroom, and the manner in which students and teachers engage each other through language. Ewing explains that mathematics is a type of discourse in which subject positions are constructed, specifically the positions of teacher and students. "Understanding identity, participation, discourse, discursive practice and positioning provides a way to investigate how students locate themselves in discourses of participation and non-participation in classrooms" (p. 183). In the study, students were interviewed about their perceptions of the mathematics program in which they were enrolled. Using the students' own words, Ewing was able to determine how they identified themselves as mathematics learners in the classroom. Students who viewed the program in positive terms had an identity of participation. Students who viewed the program discourse as negative had an identity of non-participation. "An identity of non-participation was less likely to connect with learning, which means limited opportunities to access the program discourse" (p. 184). The author concluded that participation or non-participation in mathematics discourse was often shaped and influenced by the students' social perceptions.

Garegae, K. G. (2007). *A quest for understanding understanding in mathematics learning: Examining theories of learning* . Proceedings from Ninth International Conference: The Mathematics Education into the 21st Century Project. Charlotte, NC: UNCC.

The researcher chose this study, because it discussed three main theories teachers apply when teaching mathematics; Behaviorism, Cognitivism, and Constructivism. This was relevant to the action research project, because teaching style was examined to determine if it had an effect on student participation or non-participation in mathematical discussions, as well as their understanding of the material. The findings of the study cited above brought to light how the researcher's theories of teaching and learning compare and contrast to those of other teachers. In the action research study, the researcher taught using a combination of Cognitivism and

Constructivism. The Constructivist model emphasizes the use of discourse as a means for teaching understanding, and was expected to increase students' participation in mathematical discussions.

This paper argues that, “teachers’ points of view about the nature of mathematical understanding (and of mathematical thinking) is largely influenced by their affiliation to theories of learning...These theories form lenses through which one views the world, hence impacting on his or her beliefs about teaching, learning and understanding” (Garegae, 2007, p. 234). The study examined the teaching styles of three different teachers of mathematics. The teacher “perceived to be a behaviorist, believes that mathematics understanding is achieved through doing several problems on a certain topic. His teaching is characterized by sporadic explanations to an individual or group of students and seat-work where students perform repeated calculation” (p. 235). This teacher stated, in his essays and interviews, the belief that students who can work out problems can understand mathematics. Garegae pointed out that when examining the students' exercise books, “it was found that he [the teacher] marks the answer only. He never considered the method—a practice that is contrary to his claim” (p. 235). The second teacher in the study taught by applying the Theory of Cognitivism, emphasizing mental processes when teaching. He used, “Socratic dialogue with the whole class, trying to diagnose students’ prior knowledge, which always formed a basis on which current information was built on” (p. 235-236). This teacher emphasized the importance of a student's ability to retrieve previously learned knowledge for application to a new mathematical situation. The third teacher used a Constructivist approach for teaching mathematics. In every class, he, “made sure that students engaged in discussions of some kind...he emphasized practical work and investigations, giving students an opportunity to elaborate on their thought processes” (p.236). The author concluded that a teacher's view about the reason for learning, in addition to their beliefs about mathematics, is strongly influenced by their “theoretical underpinnings on what understanding is, and how it is assessed” (p. 236).

Garii, B., & Okumu, L. (2008). Mathematics and the world: What do teachers recognize as mathematics in real world practice. *The Montana Mathematics Enthusiast,* 5 (2 & 3), 291-304.

In order to generate successful mathematical discussions in a fifth grade classroom, the teacher needs to have a solid understanding of the real-world applications of mathematics. The following study explained that, “school mathematics is the activity of participating in a mathematical practice”, and asked the question, “What happens, then, when students and their teachers do not recognize that they are participating in mathematical practices?” (Garii & Okumu, 2008, p.293). The focus of much of the literature related to teaching mathematics has to do with teaching methodology. However, this article offered a different perspective for contemplation. The responsibility for teaching students mathematics in a meaningful context is related directly to how the teacher views and recognizes mathematics in his or her daily encounters.

The authors of this study examined the problem that teachers have connecting mathematics taught in the classroom to its real-world application. “It becomes difficult to explain to children that the mathematics that is responsible for innovations, advance, and creative technological practices depends on the elementary concepts and building blocks of basic mathematics and arithmetic” (Garii & Okumu, 2008, p.292-293). Twenty-eight teachers participated in the study. They were asked to carry a notebook and record all of the mathematical encounters they had within their daily life for a week. Mathematical encounters were defined as “any recognized, concrete, mathematical event that the teacher participated in...or observed….Teachers were asked to also report their own thoughts and questions about mathematics and mathematical practices” (p. 295). The results of the study indicated that, while teachers may understand the pedagogy and content knowledge of mathematics, they may not value the mathematics they teach because they are unaware of its influence in their daily lives. “They fail to connect the mathematics and mathematical thinking they teach to mathematical practices outside their classrooms” (p. 300). This in turn affects their ability to teach their students mathematics in a meaningful context. “When teachers are able to make these connections, there is evidence that students 1) begin to recognize the role of mathematics in technology, innovation, planning, and decision-making; 2) recognize the social justice impacts of mathematical knowledge; and 3) understand that mathematics is more than just a 'right answer'” (p.293).

Gresalfi, M., Martin, T., Hand, V., & Greeno, J. (2009). Constructing competence: an analysis of student participation in the activity systems of mathematics classrooms. *Educational Studies in Mathematics, 70,* 49-70. doi: 10.1007/s10649-008-9141-5

The researcher chose this article, because it offered a different perspective on the view of mathematical competence as it relates to participation, and to the expectations put forth by the teacher and/or students. Participation and success in learning mathematical concepts may differ greatly from teacher to teacher. The authors of this study reviewed two classrooms in which the participation structure was very different. In this action research project, comparisons were made between a lecture-style of teaching and an inquiry-based style of teaching. In order to be fair, both styles were evaluated in a judicious manner. The article gave an indication that a potential for increasing participation might be achieved by allowing for student interaction, which could influence their mathematical competence.

The authors in this piece of literature were examining competence construction in mathematics classrooms. Gresalfi, Martin, Hand, and Greeno (2009) propose, “a concept of competence as an attribute of participation in an activity system...What counts as 'competent' gets constructed in particular classrooms, and therefore can look very different from setting to setting” (p. 50). The authors describe competence as what students need to know and do in order to be considered successful learners by the teacher and other students in the classroom. Students that give correct answers could be considered competent. Those that share mistakes could also be considered competent, because errors can provide a basis for learning. In most classrooms, the teacher holds the power to determine if student participation elicits competence in mathematics. However, Gresalfi et al. argue that, “the teacher is not the only participant who is able to shape the construction of competence in a classroom; the students also play a role in this negotiation” (p. 51). Classrooms that promote interaction between students require that a student work more diligently to convince his or her peers that his or her solutions make sense. Thus, students in such classrooms “may have many more opportunities to respond to questions and revise their solutions” (p. 54). The authors did a research study of two mathematics classrooms in order to further investigate their ideas. Based on their observations, they concluded that in the classroom where the students interacted with each other, their competence was measured with the “rhetoric of what is means to do mathematics”. In the other classroom, students were considered competent if they were able to follow directions and complete problems using the methods modeled by the teacher. This system of competence, “was not especially responsive to students' own ways of participating, but rather reinforced a process of engaging with mathematics in one particular way" (p. 69). The authors indicated an interest in doing further research into studying the role students play in determining mathematical competence in the classroom.

Ifamuyiwa, A. S., & Lawani, A.O. (2008). Interaction patterns in mathematics classrooms in Ogun State secondary schools. *The Online Journal of Academic Leadership, 6.* Retrieved January 20, 2010 from http://www.academicleadership.org/emprical_research/456.shtml

The researcher chose this literature, because it offered a different focus on the topic of student participation in mathematics. The authors collected data on the teachers' interactions with the students in their classrooms. The study implied that participation in mathematics is not solely the responsibility of the students, but depends greatly on the manner of instruction provided by the teacher. The conclusions made by the authors supported the hypothesis that a relationship existed between the manner in which the material was being presented, and the lack of engagement of the students. The authors also offered suggestions for alternative forms of teaching, such as inquiry-based learning and group work, to promote more student participation in mathematics lessons.

The authors of this study sought to find the answers to two questions. The first was, "what is the general pattern of interaction in the observed mathematics classrooms? (Ifamuyiwa & Lawani, 2008, para. 6). In their study, Ifamuyiwa and Lawani collected data by observing twenty mathematics teachers, ten male and ten female, paying specific attention to the verbal interaction between teacher and students during the lesson. The data indicated that both groups of teachers interacted with the students through whole class instruction. "It has been suggested that thoughtful whole class instruction can produce as much discussion and appropriate problem solving as small group instruction" (para. 3). The study also found that the students were not taught mathematics using an inquiry-based model. The second question the authors set out to n answer was, "Is there any significant difference between the classrooms interaction behaviors of male and female teachers based on (a) instruction, (b) questioning skills, (c) students responses and (d) teacher's feedback?" (para. 6) The mathematics teachers involved in the study used "mainly informational and memory questions during their classroom instruction with only a few leading and probing questions" (para. 11). The teachers in the study failed to design and formulate questions that would cause the students to become active participants in the classroom. The authors concluded that teachers of mathematics "need to engage their students in the teaching-learning process, use student-centered or interactive strategies and provide adequate feedback to their students after mathematics instructions" (para. 2). The authors also supported the use of group work in mathematics instruction and questioning that encouraged student participation.

Mously, J., Sullivan, P., & Zevenbergen, R. (2007). *Keeping all students on the learning path.* Proceedings from Ninth International Conference: The Mathematics Education into the 21st Century Project. Charlotte, NC: UNCC.

The information in this study provided the researcher with a promising practice for engaging students in meaningful mathematical learning activities. One of the points made in the article was that an inquiry-based approach to teaching still requires that the teacher have a plan in mind for meeting learning objectives. In essence, the teacher needs to predict ahead of time the potential barriers the students might encounter when actively solving mathematical problems, in order to assist them further on their paths of learning. These barriers of mathematical knowledge could be one of the underlying causes of non-participation in mathematical discussions. Having plans in place to move students beyond these barriers helped the researcher apply an inquiry-based model of teaching more effectively, and increased student motivation and participation in their learning.

The researchers of this piece of literature investigated how Vygotsky's Zone of Proximal Development (ZPD) can be applied to teaching mathematics. “Vygotsky's theory implies that the challenge for all teachers is to pose problems that most students are not able to do so, that students learn mathematics by solving problems though their own thinking, but to support those who are not ready for the level of independent problem solving required by the task” (Mously, Sullivan, & Zevenbergen, 2007, p.466). The main focus of the paper was on differentiated learning trajectories. The sixty teachers in the study were trained to use differentiated learning trajectory as part of their mathematical lesson design. Lesson design decisions were based on a teacher's best guess of how the students' learning might proceed. However, this plan was modified accordingly, in order to meet the needs of the students that encountered barriers while learning to do mathematical tasks. “Even very open-ended inquiry-based lessons have starting points and target learning objectives where the aim is to teach aspects of mathematics” (p. 466). The teachers in the study used open-ended questions to introduce mathematical topics because they were determined to have the most potential for addressing a range of students' abilities. Students who solved a task quickly were given more challenging tasks related to the same topic. Students who struggled were given prompts to assist them to the next level of understanding. The conclusions of the study were, “carefully scaffolded open-ended tasks, with accompanying enabling and extending prompts readily at hand for use as needed, can facilitate the successful movement of whole classes of students along planned learning trajectories in mathematics lessons” (p. 471).

Odafe, V. U. (2007). *Teaching and learning mathematics: Student reflection adds a new dimension.* Proceedings from Ninth International Conference: The Mathematics Education into the 21st Century Project. Charlotte, NC: UNCC.

One of the data collection tools used in the study on fifth grade student participation or non-participation in mathematics was a self-reflective questionnaire. The researcher had the students self-reflect about their contributions during math lessons. The following study provided some concrete and useful guidelines for employing the Student Reflection Process (SRP) within mathematical instruction. Based on the results of the author's study, SRP improved student participation and performance on assessments overall. SRP was an excellent tool for solving the problem of non-participation of students in mathematics. For the purposes of this research project, self-reflection was only used as a data collection tool. The reflection format described in the literature aided in the design of a self-reflection questionnaire. Following the action research project, a investigation into the effects that regular use of SRP has on student participation in mathematical discussions may be explored.

The author of this paper discussed how the process of SRP helped students improve their participation in mathematics classes. “Student reflection is defined as the process of thinking about learning by a student. It involves thoughts that the student has before, during, and after a particular lesson or lessons.” (Odafe, 2007, p.486). Odafe outlines the following four areas that are covered in SRP: metacognition, modeling, oral and written communication, and sharing of responsibilities. Metacognition involves helping the students to think about how they think, in terms of solving mathematical problems. Modeling is done by the teacher and “provides students with ideas of concepts, skills, and knowledge that they should acquire and share with peers” (p. 487). Effective oral and written communication by the students means that they are able to reflect and clarify ideas and thoughts from previous mathematical experiences. "Sharing responsibilities refers to the fact that both instructor and students should see themselves as learners and teachers" (p.487). Within his study, the author used several activities to address the four areas of SRP. These activities included having the students complete reflection surveys, and then give daily oral presentations on the main ideas, concepts, definitions, and procedures covered the day before. The students used the reflection surveys to prepare for the possibility of giving an oral presentation. The daily student presenter was chosen randomly from a hat. In addition to describing what was covered in the previous mathematics class, the students were required to "describe their contributions to the course learning activities, as well as indicate their areas of difficulties" (p. 487). They could also indicate in their survey if they needed help, or had any suggestions. The results of including SRP as part of the mathematics class were positive. The students became much more involved in their learning, and improvements were also apparent in their test scores by the end of the study. Odafe also provided a list of guidelines for implementing SRP into daily mathematical instruction. The author concluded that, "reflection provided an opportunity for the students to realize when to ask and receive help, contribute to the teaching-learning environment, and as a result, learn the materials of the course...the process is both an individual and a shared experience that results in improved student learning in an environment where they are partners in the mathematics teaching and learning process" (p.490).

Nathan, M. J., Kim, S., & Grant, T. S. (2009). *Instituting change in classroom discourse structure: Human and computer-based motif analysis* (WCER Working Paper No. 2009 -1). Madison: University of Wisconsin–Madison, Wisconsin Center for Education Research. Retrieved April 24, 2010 from http://www.wcer.wisc.edu/publications/workingPapers/papers.php

The researcher chose this piece of literature, because it explained two types of classroom discourse structure, in relation to participation in mathematics. It supported the initial ideas that mathematics instruction needed to include aspects of student-led discussion and group work, as opposed to using a lecture-based manner of presenting the material. The article also pointed out the important role that professional development and training had in assisting the teachers in the study to modify their manner of classroom discourse. The program included instruction on "active listening and other methods of achieving classroom norms conductive to student participation and student-directed learning...approaches to modeling constructive feedback...and techniques for eliciting and using students' multiple solution methods to facilitate mathematical participation and learning" (Nathan, Kim, & Grant, 2009, p. 5).

In this study, the authors examined student participation in the classroom as a result of the classroom discourse structure practiced by the teacher. "Monologic discourse focuses on response to an authority in an expected manner, often as a way of showing adherence to the canon.   Dialogic discourse, in contrast, derives from a participatory view of learning...a powerful way to promote student engagement and higher order reasoning, long-term retention, and transfer of concepts to new contexts" (Nathan, Kim, & Grant, 2009, p. 3). In order to modify monologic instruction, and to promote dialogic interactions, "the locus of authority of knowledge must be de-centered, and students granted permission to initiate discussion" (p.3). In the study, the authors provided the teacher with professional development training in order to reduce that "traditional teacher-led *initiation-response-evaluation* (IRE) patterns, and to increases in student-led *initiation- demonstration-evaluation* (IDE) patterns" (p.3). They evaluated the teacher by observing him or her throughout one year. Then they evaluated that same teacher the following year, after he or she had taken the professional development course on reform instruction. The authors were able to track and categorize their observations with the use of a computer program. In conclusion, Nathan et al. determined that, "changes in the climate of the classroom that invite greater student participation in mathematical interactions can also lead to identifiable changes in the discourse structure" (p. 10).

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning*, *10*: 4, 313-340. doi: 10.1080/10986060802229675. Retrieved January 29, 2010.

The researcher chose this article because it offered practical strategies for improving classroom discussions in mathematics, thus increasing student participation. It points out the benefits of inquiry-based learning, but also notes the problems that teachers experience. In moving from a teacher-led to student-led discussion format, it is still important that the teacher guide his or her students so that they can construct meaning from the mathematical activities that they participate in. The ideas presented in this article were useful for the development of an action plan. Another concept brought to mind by this article was that students who do not participate in mathematics discussions may lack the verbal skills needed to do so. Students who do participate could also be taught to more effectively communicate their ideas, facilitated by the guidance of their teacher.

The authors of this study outline five guidelines that teachers can use to facilitate classroom discussion and advance important mathematical ideas. “A key challenge that mathematics teachers face in enacting current reforms is to orchestrate whole-class discussions that use the students' responses to instructional tasks in ways that advance the mathematical learning of the whole class” (Stein, Engle, Smith, & Hughes, 2008, p.314). Teachers who use inquiry-based methods, in which the students construct mathematical knowledge using their own logic, need to have methods to follow up on student understanding of the material. The challenge of using discovery-based learning is “aligning students' developing ideas and methods with the disciplinary ideas that they ultimately are accountable for knowing” (p. 319). Thus, the teacher can use student-developed work to set a basis for whole class discussion, “in which the teacher actively shapes the ideas that students produce to lead them toward more powerful, efficient, and accurate mathematical thinking” (p. 320). The authors then present five practices for facilitating mathematical discussions. The five practices are:

> (1) anticipating likely student responses to cognitively demanding mathematical tasks, (2) monitoring students’ responses to the tasks during the explore phase, (3) selecting particular students to present their mathematical responses during the discuss-and-summarize phase, (4) purposefully sequencing the student responses that will be displayed, and (5) helping the class make mathematical connections between different students’ responses and between students’ responses and the key ideas (p. 321).

The authors provide an explanation for each practice, and give examples of how to apply them to the teacher's instructional practice. In conclusion, Stein et al. state that, “the five practices do not provide an instant fix for mathematics instruction...[but] a reliable process that teachers can depend on to gradually improve their classroom discussions over time” (p. 335).

Tomlinson, C.A. (2001). *How to differentiate instruction in mixed-ability classrooms* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

In the quest to increase student participation in mathematical discussions, the reseracher incorporated differentiation strategies into the inquiry-based lessons that were taught. Student participation in mathematics is dependent on their level of mathematical ability. Tasks and lessons taught using a whole class approach do not effectively meet the learning needs of all the students. The practice of differentiation allowed for more individualized and small group instruction, and was expected to increase a student's willingness to participate in mathematical discussions.

Tomlinson (2001) paints a very clear description of how to differentiate instruction to meet the needs of all the students in a classroom. "In a differentiated classroom, the teacher proactively plans and carries out varied approaches to content, process, and product in anticipation of and response to student differences in readiness, interest, and learning needs" (p.7). Content is what teachers want students to learn. "the goal of differentiating contetn is to offer approaches to 'input' [information, ideas and skills] that meet students individually where they are and vigorously support their forward progress" (p.78). Process means "sense-making...opportunity for learners to process the content or ideas and skills to which they have been introduced" (p.79). Products are alternative assessments that studenst create to demonstrate what they have learned. They should "help students—individually or in groups—rethink, use, and extend what they have learned over a long period of time" (p.85). Each of these areas can be tailored to fit students' readiness, interestes, and/or learning profiles. Students' readiness for learning is based on their abilities and prior knowledge in a subject area. "Students learn better if tasks are a close match for their skills and understanding of a topic" (p.45). Students' interest for learning is based on subject matter that they are passionate about learning. It also requires that the teacher encourages students to broaden their experiences and develop new interests. Students' learning profiles are the ways in which they learn best. This includes their preferences for group orientation, cognitive style, muliple intelligence profiles, and the physical attributes of the learning environment. Careful planning and application of differentiating strategies to meet the needs of all students ensures that they are actively engaged and participating in their learning.

Tuska, A., & Amarasinghe, R. (2007). *The effects of participating in lesson studies on practices of teaching mathematics.* Proceedings from Ninth International Conference: The Mathematics Education into the 21st Century Project. Charlotte, NC: UNCC.

The researcher chose to include this article within the literature review, because it offered a different vantage point for solving the problem of student non-participation in mathematics. The focus of the research was providing teachers with necessary professional development aimed toward improving their classroom instruction and understanding of mathematics. When the teachers improved their practice, this had a positive effect on the students' participation in mathematics and learning. The examples provided by the authors of the paper, as well as the results, supported the researcher's initial ideas that an inquiry-based approach to teaching mathematics was more effective. However, teachers need to have the proper skills, instruction, and support to change their teaching methods.

The authors of the study cited above were investigating how the proper training of the teachers through professional development, using lesson study in particular, improves student participation and achievement in mathematics. "The focus of lesson study is the design and implementation of lessons that achieve the long term, instructional and pedagogical goals set by the lesson study group" (Tuska & Amarasinghe, 2007, p.655). Teachers can use lessons study to deepen their knowledge of mathematics and pedagogical skills, and promote student centered teaching in the classroom. “Before starting lesson study, many teachers had used the traditional lesson structure...giving out homework results, then short lecture on new material through examples, followed by seat work...This approach often had failed to engage the majority of the students” (p. 654). The content experts teaching the professional development courses “encouraged experimenting with the implementation of problem solving activities, group investigations and presentations, use of technology, visualization, and manipulatives for making the students active, socially connected, and successful learners” (p. 654). Another area, with which the teachers needed help, was developing skillful questioning techniques aimed toward the whole class and small group discussions, to promote their students' active engagement in the mathematical lessons. One of the unique features of lesson study is that it involves a group of teachers working collaboratively to create mathematics lessons, monitor each other’s progress, and provide each other with feedback and support.

> In successful lesson study initiatives in the United States, teachers benefited from increased knowledge of subject matter, increased knowledge of instruction, increased ability to observe students, stronger collegial networks, stronger connection of daily practice to long-term goals, stronger motivation and sense of efficacy, and improved quality of available lesson plans. Lesson study did not only improve a lesson. It challenged teachers to improve their classroom instruction (p. 655).

The teachers benefited immensely from lesson study, and so in turn did their students. The students had improved presentation skills, motivation toward learning, and were more engaged in the mathematical discussions and lessons.

Description of Proposed Intervention or Innovation

The intervention attempted to improve the incidence of participation by fifth graders in mathematical discussions was to follow an inquiry-based model of teaching and presentation of the learning material. Greater emphasis was given to students' small group interaction and discussion of mathematics, as opposed to teacher-led, lecture-based discussions. Tuska and Amarasinghe (2007) found that teachers who experimented with, "implementation of problem solving activities, group investigations and presentations, use of technology, visualization, and manipulatives" led to the students becoming "active, socially connected, and successful learners" (p.654). Application of the five practices for orchestrating productive mathematical discussions in the classroom was done according to the guidelines provided by Stein, Engle, Smith, & Hughes (2008). Additionally, the researcher practiced the use of differentiated learning trajectories to design inquiry-based lessons and increase their effectiveness, as suggested by Mously, Sullivan, and Zevenberger (2007). A focus on real-world mathematics was also used in the inquiry-based lesson. All of the practices mentioned were applied to the whole class. Individual students who were struggling with the learning material, regardless of the method of presentation, were targeted for one-on-one, and/or small group instruction. With careful planning, lesson design, and preparation, the inquiry-based method of teaching was expected to produce the desired results of increased participation in mathematical discussions by the students in the study. The students' understanding and use of mathematical concepts was expected to improve, as well as their awareness of real world mathematics, and their ability to communicate in mathematical discussions. Evidence of these improvements was found in their performance scores on assessments, and in the observations made by the researcher while the inquiry-based learning was taking place. The study took place over the course of three months. During the first half of the study, the researcher observed the homeroom teacher teaching mathematics using a lecture format. During the second half of the study, the teacher researcher taught mathematics using and inquiry-based approach. These lessons were videotaped and observed after the completion of the data collection phase of the study.

Research Process

The following is a description of the data matrix (see Appendix A). To begin the data collection phase of this action research project, the researcher used an observation form and classroom map (See Appendices B and C), for recording incidences of student participation during mathematics lessons. These tools were designed to record a variety of different types of participation, and indicated the basic nature of that participation. They were used during every mathematics lesson that was observed in the study, and this provided a consistent source of data for analysis and comparative purposes. There were several specific observations that were recorded. Each incidence of hand raising by the students was marked as a tally. Additionally, these marks were highlighted to show if a student was called on, and whether he or she gave a response or asked a question related to the mathematical discussion, or gave an off task comment. The researcher listed which students were called to the board to work a mathematics problem, which students offered a verbal solution to a problem and explanation of their methodology, which students challenged the validity of a solution or method either by the teacher or their peers, and which students actively helped their peers. Finally, students who appeared to be completely disengaged from the lessons were also listed. Space for additional observations was included for recording notes about other events of interest that occurred.

A spreadsheet (See Appendix D) was designed in order to organize the data recorded during each mathematics lesson, and "to reduce that data to a manageable form" (Mills, 2007, p.

124). Each student's participation can be analyzed individually for that lesson. The researcher interpreted the data by looking for patterns that developed with certain students. The following questions were considered: Which students were showing a high incidence of participation? Which students participated the least during the lesson? Which students were not asking questions and what could be the reason(s) for this? Participation of the class as a whole was calculated in a spreadsheet for analysis purposes. This provided answers to other questions: Does there seem to be a lack of participation by the whole class, or only by certain students? What is the average level of participation for the lessons? Does the teaching style or mathematical topic affect the level of participation by the whole class?

After collecting, analyzing, and interpreting the data for each individual lesson, the researcher made comparisons between lessons. “When you’re interpreting your data analysis, you need to look for patterns, you need to look for themes, you need to look for the what, or to explain what you received or what happened because of your data analysis” (video: How Do I Analyze and Interpret My Data?). Using the data in the spreadsheets, trends and changes in the data were evident from lesson to lesson. For example, the first lessons under observation were taught using a lecture-based model. The results of the data from these observations were compared to observations made during lessons taught using an inquiry-based model. One of the main items of interest was whether or not student participation increased, decreased, or remained the same with the change of teaching format. Individual student's progress was tracked to see if certain students participated more or less, depending on the style of teaching.

In order to aid the researcher in evaluating the observation data, additional data collection sources were created to gather information about participation from the students' point of view. The first of these was a mathematics participation survey (See Appendix E). The students were asked to give responses to a series of ten statements related to participation in mathematics. They could respond to each question by circling one of the following words: often/sometimes/rarely/never. Each word had a point value attached to it. These points were added up to indicate how the students perceived their personal level of participation during mathematics class. A high score indicated that a student felt he or she participated a great deal during mathematics. A low score showed that a student did not feel that he or she participated to a great degree. This information was compared to the actual data recorded on the participation spreadsheet. The researcher compared the results of both to see if a student's actual level of participation matched his or her perceived level of participation.

A student questionnaire was designed for collecting qualitative data, which could be compared to the quantitative data collected on the surveys and in the spreadsheet (see Appendix F). The student questionnaire provided the students with an opportunity to voice their perceptions of participation in mathematics after each lesson that was observed. The log prompted the students to think about their participation in mathematics and express this in their own words. It also provided them with an opportunity to indicate what they have learned during the lesson, and share what areas they were still confused about and needed help with. The responses on the questionnaire were be used to gain insight to the reasons behind the students' scores on the mathematics participation survey, and the data in the spreadsheets. Their perception of what it meant to participate was one indicator of why they chose to participate in one form, instead of another. In addition, the student questionnaire gave some feedback regarding whether the students participation was affecting their understanding of the learning material. To support this the researcher also used notes taken during small group work and samples of activity sheets completed by the group members, collectively and/or individually, depending on the tasks given during a particular lesson. Comparisons were also made between the levels of participation and understanding that the students reported during lecture-based instruction and inquiry-based instruction. A change in the nature of participation between the two teaching styles was expected.

To further investigate how participation affected the students' understanding of the material, homework, tests, and quiz scores were analyzed and interpreted. The data collection instruments used for each observation had an area indicating the topic of the lesson, and any accompanying assessments that correlated to the topic. The researcher looked to see if the students' assessment scores improved as their participation increased, whether the scores remained unchanged, or whether they declined. For example, if a student showed an increase in participation, but his or her grades remained unchanged, a determination was made whether increased participation had any effect on their learning, or if there were other factors at work causing the conflicting results. The self-reflection questionnaire was a key source of information for interpreting the data and making reasonable conjectures. It is important to note that the researcher only looked at assessment results that were directly linked to lessons taught during the research period. Student scores prior to the start of the study were not included, because data to correlate with these results was not recorded.

Finally, the researcher gave the students a culminating survey at the end of the research project (see Appendix G). The statements on this survey were designed to get the students' opinions on which style of teaching they preferred. The responses on this survey were compared to the overall results of the other data collection instruments. If the results concluded that a student participated more during the inquiry-based lessons, the researcher looked at the data collected to confirm this.

Data Analysis

The following data analysis was done in order to find the reasons behind fifth grade students' participation or non-participation in mathematical discussions, to determine if this has an effect on their learning of the material. Twenty-four fifth graders participated in the study. The classroom teacher conducted all of the lecture-based lessons and the teacher researcher conducted the inquiry-based lessons. The results of this study are presented below.

The first question the researcher sought the answer to was, which students were participating during mathematics lessons, and in what manners? The data indicated a variety of forms of participation in which students partook. This included raising their hands, answering and/or asking questions, solving problems on the board, and completing tasks in small group activities. Prior to conducting this study, the researcher determined that a majority of the students were not actively participating in the mathematics lessons presented by the teacher. Examining the amount of the students' participation, the nature of that participation, and the students' perceptions of how much they participate, indicated that all of the students participated in some form or another during both the lecture-based and inquiry-based teaching formats.

For data analysis purposes, the students' overall averages of participation during the course of the study were recorded in spreadsheets. This information was taken from observation forms and classroom tally maps (See Appendices B & C) that were filled in during the data collection phase. The following information provides significant statistical data related to the incidence of students raising their hands to participate during the lecture-based mathematics lessons (See Appendix H). The average amount of hand raising was twenty-six times. Fourteen students participation scores fell below the mean and ten were above the mean. Four students showed a high incidence of participation overall by raising their hands in the range between fifty and seventy times. Eighteen students participated by raising their hands in the range of thirteen to thirty-three times. Two students raised their hands ten or less times. Student responses and questions were included in the overall tally of raised hands. Twenty percent of the students gave responses during the lecture-based lessons, and two percent of the students asked questions related to the mathematical discussion.

The next set of data provides significant statistics related to the incidence of students raising their hands to participate during the inquiry-based mathematics lessons (See Appendix I). The tally marks for participation during this form of instruction were significantly lower than those recorded during the lecture-based lessons. This disparity will be examined at a later point in this analysis. During the inquiry-based portion of the study, the average amount of hand raising was nine times. Sixteen students participation scores fell below the mean, and eight were above the mean. Six students showed a high incidence of participation overall by raising their hands in the range between fifteen and twenty-five times. Fourteen students participated by raising their hands in the range of three to twelve times. Four students raised their hands two to zero times. Student responses and questions were also included in the overall tally of raised hands during the inquiry-based lessons. Fourteen percent of the students gave a responses during the lessons, and eight percent of the students asked questions related to the mathematical discussions.

The students also participated in the mathematics lessons through random selection when the teacher pulled their name card to solve a problem on the board. The average amount of card calls during the lecture-based lessons was 2.67 times. Fifteen students were within one standard deviation of the mean, and eight students were within two standard deviations of the mean. Overall, the distribution of data through this form of participation was more evenly dispersed amongst the whole class. During the inquiry-based lessons, the average number of card calls for solving problems on the board was 0.33 times. Due to the nature of this style of teaching, calling random students to the board to write and solve problems was not often used. The teacher used purposeful selection of students for sharing problems on the board to guide the mathematical discussion in a particular direction.

With the supporting evidence from the written notes and observations recorded by the researcher, several conclusions can be drawn in relation to the information provided above. During the lecture-based lessons, all of the students participated in some form and at some point during the course of this part of the study. However, the levels of hand raising vary greatly from student to student. The observations made by the researcher indicate that the students whose participation was above the mean had the greatest impact on the mathematical discussions that took place. In order to confirm their active involvement in the lessons, the observations and notes taken during each lecture-based lesson were crosschecked. The notes confirm that the students who were actively participating at higher rates were sharing their own solutions to problems, asking questions pertinent to the mathematical topics, and at no point appeared to be disengaged during the lessons. Of equal concern are the students whose participation was below the mean. These students consistently participated at a lower rate for each of the lessons observed. Two of the students who had a very low incidence of participation were also observed as being disengaged during the lessons. However, this was not true for all of the students whose participation fell below the mean. Reviewing these students' responses on the mathematics participation logs indicated that they were engaged in the lessons, even though they may have not raised their hands as often as their peers. The reasons for their reluctance to actively participate in the lessons was not made apparent through the research.

During the inquiry-based lessons, the nature of participation was quite different from the lecture-based lessons. The students spent most of the learning time working in small groups to complete mathematical tasks. The researcher observed students working together to solve the problems placed before them. All of the students appeared to be engaged during these group activities. The notes confirm that all of the students were actively participating by sharing their own ideas and solutions to problems, asking questions pertinent to the mathematical topics, and at no point appeared to be disengaged during the lessons. The tallies on the classroom maps do indicate that two students did not participate at all during whole group discussion. However, these students did actively participate within their small groups. Their lack of participation during whole group instruction remained consistent and may require further investigation.

The mathematics participation survey provided some insight into how the students rated their level of participation in mathematics (See Appendices E & J). A one hundred percent rating would indicate that a student felt they participated a hundred percent of the time. This would result in a student circling “Often” on the survey for every statement. Any other combination of responses would result in a score that is less than one hundred percent. With this being said, the average score on the mathematics participation survey was seventy-eight percent. The scores ranged from fifty-five percent to ninety-five percent. When comparing how the students rated their level of participation to their actual participation, it was discovered that thirteen students participated less than what they perceived. Two students actually participated more than they thought they did, and nine students' participation rates matched equivalently with their survey scores. The four students who showed the highest incidence of actual participation also scored eighty percent or above on the survey. This indicates that they are aware of their active involvement during mathematical lessons. Of the students whose levels of raised hands were twenty or less, only two scored below the mean on the survey. These two students were aware that they did not participate to a high degree during mathematics lessons. The other eight students earned survey scores of seventy percent to eighty-eight percent. However, this perceived level of participation was much less than the actual level recorded by the researcher. This indicates that the students believe they are participating at an average to above average rate, even though their actual participation is indeed below average. The difference could also signal that the students have a different understanding of what it means to participate than what was documented throughout the study. For example, one student earned a score of eighty-eight percent on the mathematics participation survey, but his level of overall recorded participation was only thirteen. In the written responses on the mathematics participation logs, he indicated "I solved problems in my head when it was not my turn." Thus, he was actively engaged in the lessons, even though he did not outwardly appear to be engaged by raising his hand to respond to questions posed by the teacher.

The second question the researcher sought the answer to was, "What effect does participation have on student understanding of the learning material?" In order to find clues to answer this question, the researcher reviewed assessment data related to the lessons taught, read through the responses that students wrote in their mathematics participation logs, and examined the activity sheets that the students completed during small group activities. Though the research was compelling in some areas, the results of this portion of the data were inconclusive.

Student homework and test results were used to determine the degree of understanding that each student had of the material presented during the lecture and inquiry lessons. This data was calculated in the form of percentages, and then compared to the participation tallies previously recorded. Following the lecture-based lessons, the overall average percentage score on the students' assessments was 81%. Eleven students had scores above the mean and thirteen students had scores below the mean. When compared to the overall participation scores, fifteen students' levels of participation were consistent with their assessment scores. In other words, six students with above average levels of participation also scored above average on their assessments. Also, nine students with below average levels of participation scored below average on their assessments. These scores seem to indicate a trend that students who participate more during mathematical lessons perform higher on assessments related to the learning material, and students who participate less have lower performance scores on their assessments. However, nine students produced inconsistent results. Four of these students participated at a level above average, but their assessment scores were below average. Additionally, the other five students participated at levels below average, but their assessment scores were above average. Therefore, the potential trend cannot be proven without further data to support it.

Following the inquiry-based lessons, the overall average percentage score on the students' assessments was 84.9%. Fifteen students had scores above the mean and nine students had scores below the mean. When compared to the overall participation scores, ten students' levels of participation were consistent with their assessment scores. Seven students with above average levels of participation also scored above average on their assessments. Four students with below average levels of participation also scored below average on their assessments. Fourteen students produced inconsistent results. Two students participated at a level above average, but their assessment scores were below average. The other fourteen students participated at levels below average, but their assessment scores were above average. One of these students did not participate at all by raising her hand, yet she had an average score of eighty-two percent.

Based on the comparison of the assessment results and the participation tallies, the following conclusions can be made. The high numbers of inconsistent results between the students' participation tallies and assessment scores does not give a definitive answer to the question of whether participation directly affects understanding. However, there were enough incidences of a consistent correlation between participation and assessment performance that warrant additional research in this area, in order to prove or disprove the theory of participation affecting student understanding.

To further investigate the effect of participation on performance, the students' mathematics participation logs were evaluated (see Appendix E). The first question on the log that the researcher reviewed was, “Are there any activities that helped you learn during today's lesson?” Following the lecture-based lessons, students either responded “No” to this question, or gave a variety of other responses. Examples of these responses include, taking notes, viewing examples on the board, and practicing skills helped with their understanding of the topic. During the inquiry-based lessons, “No” was also a common response to this question. The students who did not write "No" explained that working in a small group setting helped them with their understanding of the material. The other question that was examined on the logs was, “Do you have any questions about the mathematics lesson today that you need help with?” All but three students responded “No” to this question for all of the lecture-based lessons. The three students mentioned wrote that they needed additional help working with a protractor to measure angles. It is interesting to note that two of these students also scored high on the participation tallies and assessments. The question that this raises is whether or not the students who did poorly on the assessments might have benefited had they asked questions during the lesson or on their logs. The responses to the second question during the inquiry-based lessons was also “No” for twenty-two of the students. Only two students wrote about concepts that they still needed help understanding. In this instance, all but two of the students who responded “No”, as well as those who had questions, averaged scores well within range of the mean score of 84.9%. This raises the question of whether working in small groups improved their overall understanding of the material. Answers to this question will be explored later in the analysis.

The final pieces of data that were used to assess student understanding of mathematical concepts were activity sheets that were completed during small group work. The first inquiry-based task that the students completed was to classify triangles into the common categories of side length or angle measurement. There were eight groups of three working on this particular task. Four of the eight groups successfully categorized the triangles by either their side lengths or angle measurements. The other four groups came up with solutions that were incorrect. During the whole group discussion, the students had the opportunity to share and defend their solutions. The notes and observations during this portion of the activity indicate that all of the groups actively participated on developing a solution to the problem, even if it was incorrect in some cases. Discussion of these varied solutions to the same problem allowed the students to make a consensus on the correct classification process. Therefore, the students who were correct were justified in their answers, and the students who were incorrect were able to alter their original understanding of the problem.

The second task as part of an inquiry-based lesson that the students completed was converting mixed numbers. The students were organized into groups of five and one group of four. During this activity, each member had to contribute to the group effort by converting a given number to a different format. Once a group correctly changed the number into all of its forms, the group was given a new number to solve. An interesting observations was made during this activity. The group members worked on their individual problems at the start of the activity, but by the end of the activity, all of the groups changed their mode of participation to a whole group collaboration approach. The students who were struggling with particular tasks were supported and given instruction from their peers.

Finally, the third inquiry-based lesson task was to devise a mini-lesson related to a review of fraction concepts. In this task, the students worked with one group to create their mini-lesson on a topic: such as, how to find the least common multiple of two fractions. The students were then divided into new groups. In the new group, they had to teach their mini-lesson to their peers. Each member of this group taught a lesson on a different fraction concept. Making each individual student responsible for teaching their mini-lesson to their new group ensured that all of the students had to actively participate. In other words, they could not rely on one person to take the lead while they sat back and observed. Looking through the activity sheets in which the students outlined their lessons indicated that some of the students misunderstood the task at hand. Instead of devising a lesson, they wrote out answers to their problems with no explanation. It turned out that these five students belonged to the same group. This group did not read all of the directions for completing the task. The other nineteen students demonstrated correct understanding of the task. Each of their activity sheets outlined a step-by-step process for teaching their fraction concept.

The third question the researcher sought the answer to was, "What effect does the presentation of the material by the teacher have on participation?" In order to determine this, the researcher calculated participation averages for both teaching styles into a spreadsheet for comparison purposes (see Appendix K). Notes and observations that were taken during the lessons also were reviewed. In addition, the students' responses on the Mathematics Learning

Survey were tallied and examined for trends (see Appendices G & L). The findings in this portion of the data analysis were perhaps the most interesting and promising in terms of determining how to increase student participation in mathematical discussions.

The tally marks for participation during the inquiry-based lessons were significantly lower than those recorded during the lecture-based lessons. In order to compare the two in an equitable manner, percentages were calculated. The overall total for students raising their hands during the lecture-based lessons was 81.27%. This was calculated by adding the tallies for hand raising during all of the lecture-based lessons, and then dividing that number by the total number of tallies overall. Following the same process for the inquiry-based lesson data, the total for students raising their hands was slightly lower at 79.91%. This means that during the lecture-based lessons, more students participated through the means of raising their hands than did during the inquiry-based lessons. However, these numbers do not include the students who gave responses, asked questions, or gave an off task comment. Each of these types of communications was also calculated as part of the whole participation total. The total responses given by students during the lecture-based lessons were 20.03%. During the inquiry-based lessons, this number was lower, at 14.02%. The total number of questions during the lecture-based lessons was 2.12% and during the inquiry-based lessons was 7.94%. The off tasks comment totals were 2.12% for lecture and 0.93% for inquiry. Finally, the average percent of participation by the students was exactly the same for both types of teaching at 4.17%.

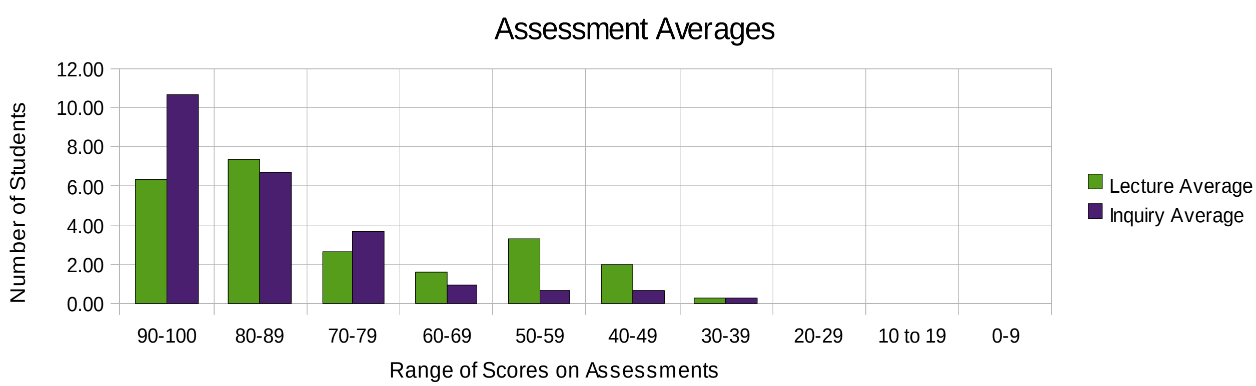
Several conclusions can be drawn from the percentages above. The first is that participation through the means of students raising hands is much greater than other forms of participation during the lecture-based lessons. However, the ratio of individual student participation remained the same. The conversation was distributed more evenly throughout the classroom during the inquiry lessons, with more students participating at a higher rate, which caused the average to remain unchanged. During the lecture-based lessons, students also gave more responses than during the inquiry-based lessons. However, during the inquiry-based lessons, the students asked more questions. This could be negative or positive, depending on the nature of the questions. If students were asking questions out of confusion, then this would suggest the inquiry-based lessons were more difficult for them to understand. If the students were asking questions to extend the topic or clarify their existing understanding, this would be considered a positive outcome of the inquiry-based instruction. Looking through the notes and observations for these lessons indicated that the latter is true. By asking more questions during the inquiry-based lessons, more students were demonstrating that they were actively involved in the mathematical discussion. The same could be said of the response percentages being higher during the lecture-based lessons. Yet, the notes and observations show that many of the responses were the students sharing answers from their homework, and not a product of higher-level thinking. The incidence of off-task comments was lower during the inquiry-based lessons. This may be coincidental, or it could also have been an indication that the students were more engaged in the mathematical discussions taking place. Disinterest in the lecture-based instruction format may have resulted in more students making off task remarks. To investigate this further, notes and observations taken during the lessons were reviewed.

The following are notes and observations regarding the nature of students' participation during the lecture-based lessons. The majority of the class time was devoted to the teacher asking questions and the students raising their hands to respond. The teacher dominated the mathematical discussions, and had control over which students participated verbally by calling on them when they raised their hands. The researcher also observed that the teacher prompted the whole class to respond to questions, in addition to calling on individual students. Also, most of the instructional time was spent checking the students' homework from the night before. Following this activity, the teacher introduced the new mathematical topic of study in the time remaining.

The notes and observations regarding the nature of students' participation during the inquiry-based lessons were much different. The majority of the class time was devoted to small group tasks followed by large group discussion. The students directed the mathematical discussions within their small groups, and the teacher circulated through the room to provided feedback, answered questions, and/or posed a different approach for the students to consider. One drawback of this form of instruction was that the lessons consistently ran over the time allotted for mathematics. This indicates that using an inquiry-based teaching model may require that more time be allotted for mathematics instruction and/or the lessons may need to be completed over the course two or more days. Finally, the researcher also observed that the teacher prompted the whole class to respond to questions, in addition to calling on individual students during the whole group discussion time.

In general, the students were observed as being more actively engaged in the inquiry-based lessons than in the lecture-based lessons. The nature of participation was inherently different. The teacher-led approach in the lecture format resulted in the teacher having a monopoly on the mathematical discussion. The student-led approach in the inquiry format gave the students the power over the mathematical discussions, with the teacher serving as a guide. Rather than offering a preference for one method or another, the data regarding student understanding of the mathematical material needed to be considered. Previously, a question was posed regarding whether the students' understanding improved through the use of small groups in the inquiry-based approach when compared to the lecture-based approach. The assessment averages that were calculated show that ten students' performances showed decreases ranging from 0.3% to 9.2%. Fourteen students showed increases in their assessment averages from 1% to 16.2%. Figure 1 illustrates the overall results in assessments for both teaching styles. These numbers support the conjecture that teaching using an inquiry-based approach did indeed improve student understanding of mathematics. Whether this could be attributed to the nature of participation or the topics being covered is debatable. The findings of this study do not prove either point, but do suggest the need, once again, for further investigation.

Figure 1



The students were given the opportunity to voice their preferences related to teaching style on the Mathematics Learning Survey (see Appendices G & L). Based on the students' responses, the lecture-based teaching format scored higher overall than the inquiry-based teaching format. Only six students favored inquiry-based instruction over lecture. Three students scores on the survey remained unchanged and fourteen students rated lecture-style over inquiry-based teaching. One statement on the survey that had an intriguing response was statement number four. It stated, “I find mathematics more interesting when I get to work with other students.” Four students strongly agreed with this statement, five students agreed, eight students were undecided, three disagreed, and two strongly disagreed. The expectation was that the majority of the students would strongly agree or agree to this statement based on the positive interactions that took place during the small group work. Statement number six stated, "I understand mathematics better when I work with a partner or in a small group." Once again, the responses were somewhat surprising. Four students strongly agreed, seven agreed, five were undecided, five disagreed, and two strongly disagreed. The improvements in the students' assessment averages would lead to the conclusion that the small group work during the inquiry-based lessons helped to improve student understanding. Therefore, the expectation was that more students would respond positively to this statement. No interviews were conducted to find the reasons for the students' responses, and the survey does not offer any additional clues to why the students favored the lecture related statements over the inquiry-based ones. One theory is that the students misinterpreted what the statements were implying. Another theory is that the inquiry-based small group work put greater emphasis on the students taking responsibility for their learning. The tasks that were given required higher level thinking strategies, and could have been perceived as more difficult. A third theory is that the students were simply more comfortable with the lecture format because it was what they were used to. The inquiry-based format may have been new to the students, and therefore it may have increased pressure on them to perform well.

The purpose of this study was to investigate the reasons behind fifth grade students' participation or non-participation in mathematical discussions, and determine whether this had an effect on their learning of the material. The research was able to answer, which students were participating and in what manners. The numbers presented gave an indication that all of the students were participating in mathematical discussions for both styles of teaching. The rates of that participation and the nature of the participation were different from student to student and from lesson to lesson. The research was inconclusive regarding whether participation in mathematical discussions had an effect on the students understanding of the learning material. The action plan will give insight to changes that could be implemented in the manner of how the data was collected in this study, in order to provide a more definitive answer to this question. Lastly, as to what effect the presentation of the material has on student participation, the following can be surmised. During the lecture-based lessons, the participation was widely dispersed and teacher directed. During the inquiry-based lessons, the participation was shared more evenly among the class as a whole, and was student directed with support from the teacher. This would indicate that the inquiry-based method of teaching produced more favorable results in terms of total student participation than did the lecture-based format. On a final note, all of the students, with the exception of one who was undecided, strongly agreed or agreed to the following statement; I think that participating in mathematics lessons helps me to learn mathematics better. This indicates that the students believe participation is an essential part of their learning. Making the students aware of their actual participation could possibly motivate them to increase it, with the hope of improving their mathematical understanding.

Action Plan

Finding an answer to the question of whether student participation in mathematics directly affected their understanding of mathematics was not an easy task. However, I have learned a great deal through this process and have several ideas for changing how I would conduct subsequent studies on participation in mathematics. I also gained experience in teaching inquiry-based mathematics, and feel that this method of teaching is the most effective for promoting student participation in mathematical discussions in a variety of forms.

Many of the results of my action research study on student participation or non-participation in mathematical discussions were inconclusive. One reason for this was that there was not enough data to give a definitive answer to whether a student's amount of participation directly affected their understanding of the learning material. In order to obtain more data to prove or disprove this theory, I would conduct this study for a much longer period of time, over the course of six months or more. Another issue that affected the amount of data I was able to obtain was the fact that I was not in the classroom recording data or teaching mathematics on a daily basis. Collecting data over the whole course of a particular mathematics unit would have possibly shown some more consistent results. I think that trends in a larger set of data would be easier to identify as well. Another flaw in my design was that the data collection tools did not gather all of the information I needed to find definitive answers to the research questions. Much of the data I collected resulted in the creation of more unanswered questions. For example, the student Mathematics Participation Logs and the surveys gave me information, but did not provide me with the reasons behind students' responses. Interviewing the students would have given me some more insight as to what they considered to be participation, how they interpreted the survey statements, and why they responded in the manners that they did. Prior to designing my data collection tools, I thought of having the students describe what they thought it meant to participate, as well as give them the opportunity to track their own participation. This might be something I would consider adding to my array of data collection tools if I were to conduct this study again. Another possible route to better this study would be to change the Mathematics Participation Logs to include statements describing forms of participation, which the students could circle. Leaving the responses opened ended left room for the students to be brief and non-specific. This made it difficult to analyze the qualitative data. Having the students circle such things as “I raised my hand”, “I answered a question”, “I asked a question”, “I explained something to a friend”, “I solved a problem”, etc., might encourage them to broadened their descriptions of how they participated in a lesson.

One of the lingering questions that I still have about my study results is whether the inquiry-based teaching style was truly more effective for teaching students mathematical understanding than the lecture-based style. My study results seemed to give a slight indication of this, but I wonder if it had more to do with the subject matter that was taught, than the actual mode of teaching. Were the students’ assessment results lower for the lecture-based lessons because the mathematics topics that were covered were more difficult to comprehend? In a future study, I would use two groups of students. All of the students would be learning the same mathematical topics at the same time, but in a given teaching style. One class would learn only through lecture, and the other class would learn only through inquiry. Differences in the assessment scores between the two groups would give a stronger indication of whether or not one style of teaching is more effective than the other.

Based on the nature of the participation that took place during the two different lesson styles, I would choose to teach mathematics using an inquiry-based approach in the future. I saw that the students were more engaged and actively participating in the inquiry-based lessons, and this is the sort of learning environment I prefer to have in my classroom. As a teacher of mathematics, I would like to seek additional support through professional development and training in the inquiry-based style of teaching. Part of the success or failure of using this method comes down to the teacher’s comfort level in applying it. In my study, I had to take a great deal of time to prepare the inquiry-based lessons so that they were orderly and effective. However, despite my best efforts, there were still things that I learned through trial and error that I could definitely improve upon for next time. One of the most significant revelations I had was that the amount of mathematical material covered in one lesson could have been covered over the course of several lessons. This was true for all of the lessons that I taught in the study. For example, in one lesson I was expected to teach the students how to classify triangles by side length and angle measurement, that the sum of the measures of angles of a triangle are 180 degrees, and do problem solving activities related to triangles. Using an inquiry-based approach took considerably longer than lecturing. Dividing this lesson into three lessons would have allowed the students more time to explore using triangle manipulatives and process the new concepts they discovered. It also would have helped them to build upon their existing knowledge lesson by lesson, as opposed to bombarding them with all the information at once. Teaching for understanding takes thoughtful planning and adequate time for the students to learn new concepts.

Over the course of this action research project, I have learned by doing. Anytime one takes on an endeavor such as this, it is impossible not to look back and wish he or she had done things somewhat differently. Even though I did not find all of the answers to my questions, the process has bettered me as an educator. Designing and implementing this project allowed me to extend my creativity and explore the teaching methods I never had time to implement when I was a fulltime teacher. Sifting through the data in search of results was time consuming, but also thrilling as I looked for trends. This has been an exciting process throughout, and it has changed my outlook on teaching and learning. In the beginning of this entire process, I had some difficulty finding literature on participation in mathematics to support my theories. Therefore, I plan to share the results of my study with the greater educational community by submitting this paper to the Education Resources Information Center (ERIC) in the hope that other teachers can benefit from what I have learned.

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Appendix A

Data Collection Matrix

Research Questions	Data Source		
	1	**2**	**3**
1. Which students are participating and in what manner(s)?	Classroom tally maps of participation and spreadsheets	Written field notes and observation forms	Mathematics Participation Survey
2. What effect does participation have on student understanding of learning material?	Collection and analysis of assessment data (homework, tests, and quizzes)	Student questionnaire-post lesson reflection on participation in mathematics and understanding of material	Notes and observations during small group work and group activity sheets
3. What effect does presentation of material by teacher have on participation?	Lesson Average spreadsheets	Notes and observations during lecture-based and inquiry-based lessons	Mathematics Learning Surveys and spreadsheet

Appendix B

5th Grade Mathematics Participation Observation Form

Date:_____________________
Topic of Discussion:____
Teaching Style:____
Assessments: ____
Absent Students:____

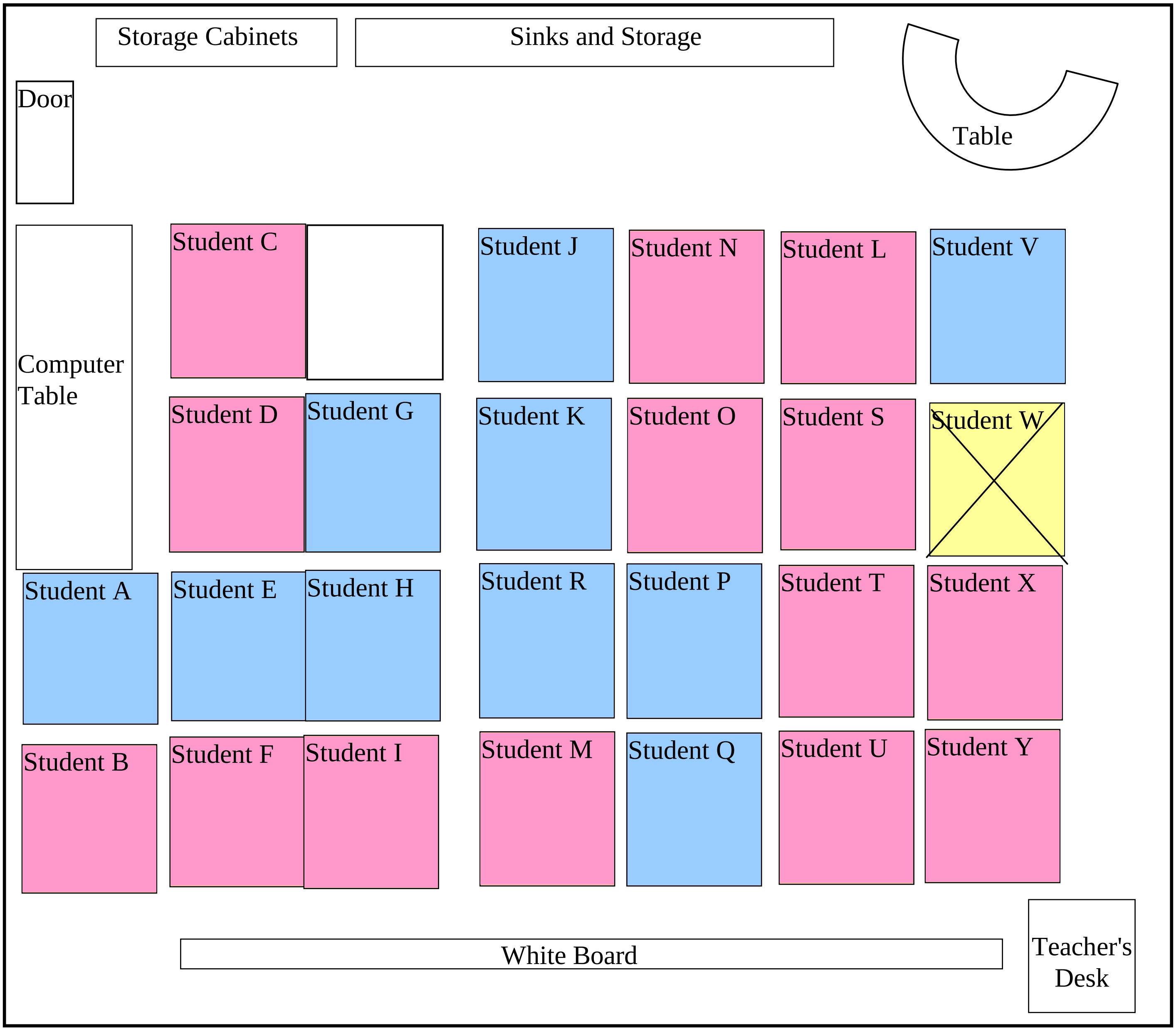
Students who solve problems on board	Students who share their own solution(s)
Students who sign up for mathematics help	Students who help their peers with mathematics
Students who question validity of an answer	Students who appear disengaged

Other Notes and Observations:

____
____
____
____
____
____
____
____
____
____
____
____

Appendix C

5th Grade Mathematics Participation Map



Map Key

Boy
Girl
Pulled for Math
Empty Seat
X Student Absent
| Raised Hand- 1 Tally
| Response **| Question**
| Off Task Remark

General Session Information

Date: ______________________________
Total Students Present-_____
Total Boys- _____
Total Girls- _____
Teaching Style: _______________________
Topic of Discussion:___________________
Assessments:__________________________
____

Appendix D

5th Grade Mathematics Participation Log	
Date of Observation:	Topic of Discussion:
Total Students Present:	Assessments:
Total Boys:	Teaching Format:
Total Girls:	

Student	Gender	Responses	Questions	Raised Hand	Off Task	Total	Card Calls/Board Work	Other Forms of Participation/Notes	Assessment
Student A	M					0			
Student B	F					0			
Student C	F					0			
Student D	F					0			
Student E	M					0			
Student F	F					0			
Student G	M					0			
Student H	M					0			
Student I	F					0			
Student J	M					0			
Student K	M					0			
Student L	M					0			
Student M	F					0			
Student N	F					0			
Student O	F					0			
Student P	M					0			
Student Q	M					0			
Student R	F					0			
Student S	F					0			
Student T	F					0			
Student U	F					0			
Student V	M					0			
Student W	F	NA	NA	NA	NA	NA	NA	NA	NA
Student X	F					0			
Student Y	F					0			
CLASSROOM TOTALS		0	0	0	0	0	0	Average	

Appendix E

Mathematics Participation Survey

Please answer the following items by drawing a circle around the word that best fits you personally. Think carefully about each statement, and give honest answers. This will not be graded, and there are no right or wrong answers.

1) I raise my hand to give an answer when the teacher asks a question in mathematics.
Often Sometimes Rarely Never

2) I raise my hand to ask questions in mathematics class.
Often Sometimes Rarely Never

3) The teacher calls on me when I raise my hand in mathematics class.
Often Sometimes Rarely Never

4) I volunteer to solve mathematics problems on the board and/or share my methods.
Often Sometimes Rarely Never

5) I find the topics in mathematics interesting and enjoy participating.
Often Sometimes Rarely Never

6) Participating during the mathematics lesson helps me to understand mathematics better.
Often Sometimes Rarely Never

7) I ask for help with mathematics when I am confused.
Often Sometimes Rarely Never

8) I discuss what I learn in mathematics with my teacher.
Often Sometimes Rarely Never

9) I discuss what I learn in mathematics with my friends.
Often Sometimes Rarely Never

10) I discuss what I learn in mathematics with my parents or family members.
Often Sometimes Rarely Never

Thank you for participating in this survey!

Appendix F

Mathematics Participation Log

Directions: Please complete each of the questions and responses below. Be as specific as you can. You do not have to use complete sentences, and may list your responses if you like. If you need help understanding what a question is asking for, please ask. This will not be graded.

1) What was today's mathematics lesson about?

2) During the lesson today, how did you participate in the lesson and/or discussion? (List as many ways you can think of. For example, asking or answering a question, helping a fellow student, solving a problem on the board, your contributions during group or partner work, etc.)

3) Are there any activities that helped you learn during today's lesson? Please list them and tell why they helped you.

4) Are there any activities that you found were confusing and did not help you learn? Please list them and tell why they were not helpful.

5) Do you have any questions about the mathematics lesson today that you need help with? Please list them.

6) Do you have any ideas for improving the mathematics lesson that would help you learn better? Please share them.

Appendix G

Mathematics Learning Survey

Directions: Please respond to the following items by drawing a circle around the response that most closely fits with you opinion: strongly agree, agree, undecided, disagree, strongly disagree. If you need help understanding a statement, please ask. This will not be graded.

1) I participate more in mathematics when the teacher is teaching and asking the questions.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

2) I participate more in mathematics when I work with a partner or small group.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

3) I find mathematics more interesting when I watch and listen to the teacher teach.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

4) I find mathematics more interesting when I get to work with other students.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

5) I understand mathematics better when I watch and listen to the teacher.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

6) I understand mathematics better when I work with a partner or in a small group.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

7) I understand mathematics better when I get to use mathematics tools (like fraction strips and triangle).

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

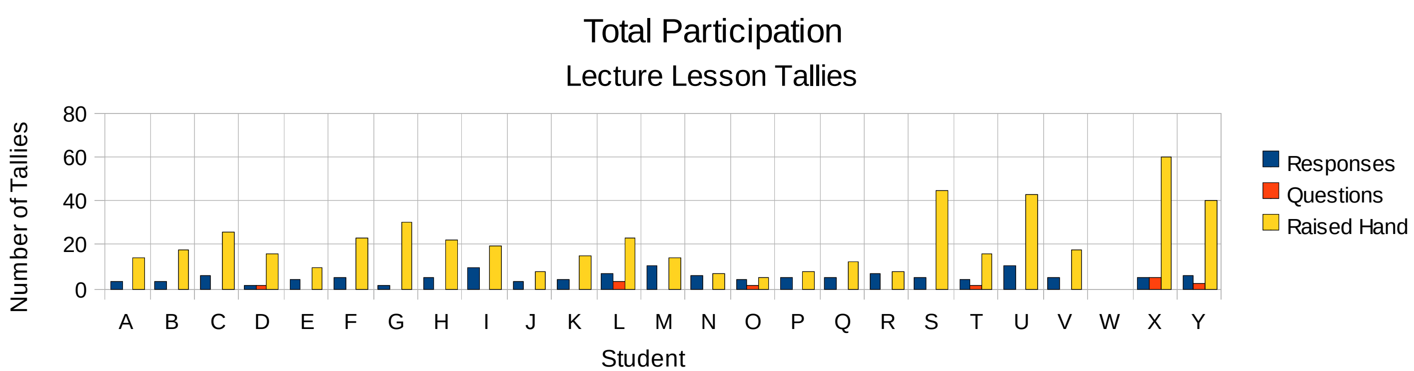
8) I think that participating in mathematics lessons helps me to learn mathematics better.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree*

Other Ideas: (Include any other things that help you to understand and/or enjoy learning mathematics).

Appendix H

5th Grade Mathematics Participation Spreadsheet									
TOTAL OVERALL LECTURE TALLIES									
Student	Gender	Responses	Questions	Raised Hand	Off Task	Total	Card Calls/Board Work	Assessment Averages
Student A	M	3		14		17	2	87.5
Student B	F	3		18		21	2	87.0
Student C	F	6		26		32	4	92.0
Student D	F	1	1	16		18	2	105.0
Student E	M	4		9		13	2	91.0
Student F	F	5		23		28	3	67.0
Student G	M	1		30		31	2	84.0
Student H	M	5		22		27	3	71.5
Student I	F	9		19	2	28	3	78.0
Student J	M	3		8		11	1	79.0
Student K	M	4		15		19	3	68.5
Student L	M	7	3	23	2	33	2	89.5
Student M	F	10		14		24	3	68.5
Student N	F	6		7		13	5	67.5
Student O	F	4	1	5	2	10	3	77.0
Student P	M	5		8		13	2	87.5
Student Q	M	5		12	2	17	4	88.5
Student R	F	7		8	2	15	1	71.0
Student S	F	5		45		50	3	43.0
Student T	F	4	1	16	1	21	2	90.5
Student U	F	10		43		53	2	91.0
Student V	M	5		18	1	23	4	43.0
Student W	F	NA	Pulled	NA	NA	NA	NA	NA
Student X	F	5	5	60		70	4	48.5
Student Y	F	6	2	40	1	48	2	48.5
CLASSROOM Average		5.13	0.54	20.79	0.54	26.46	2.67	76.0

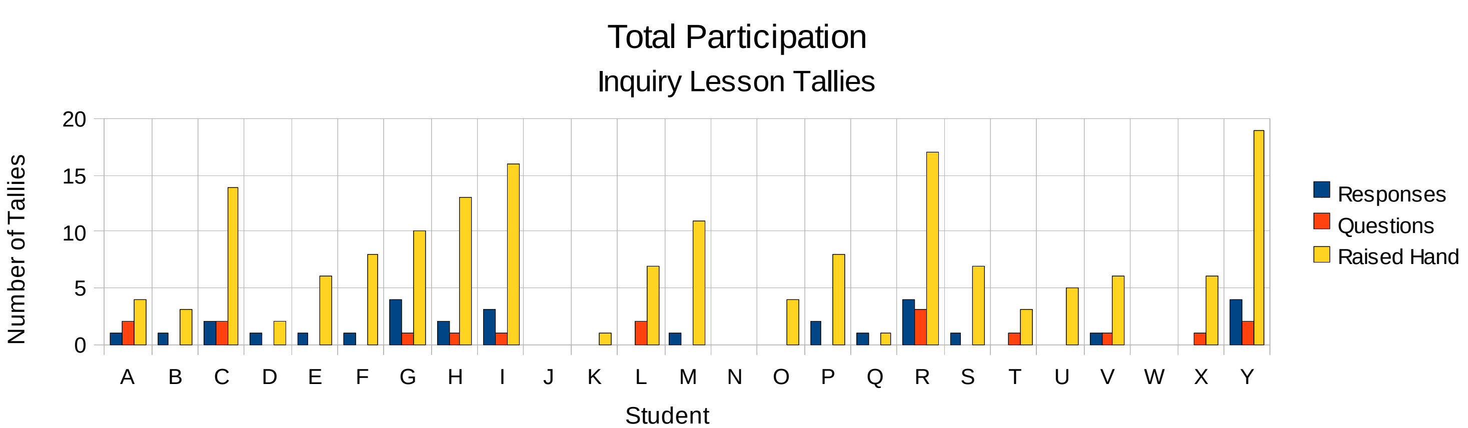


Appendix I

5th Grade Mathematics Participation Spreadsheet

TOTAL OVERALL INQUIRY TALLIES

Student	Gender	Responses	Questions	Raised Hand	Off Task	Total	Card Calls/Board Work	Assessment Averages
Student A	M	1	2	4		7		84.5
Student B	F	1	0	3		9		85.0
Student C	F	2	2	14		15		80.0
Student D	F	1	0	2		16	1	87.0
Student E	M	1	0	6		20		90.7
Student F	F	1	0	8		0	1	85.7
Student G	M	4	1	10		1		99.7
Student H	M	2	1	13		9	1	97.0
Student I	F	3	1	16		12		86.3
Student J	M	0	0	0		0	2	75.7
Student K	M	0	0	1		4		89.3
Student L	M	0	2	7	1	10		92.7
Student M	F	1	0	11		2		67.3
Student N	F	0	0	0		24	1	82.0
Student O	F	0	0	4		8	1	82.3
Student P	M	2	0	8		4		81.3
Student Q	M	1	0	1		5		66.3
Student R	F	4	3	17	1	8		86.7
Student S	F	1	0	7		0		85.7
Student T	F	0	1	3		7		94.0
Student U	F	0	0	5		25		86.7
Student V	M	1	1	6		9.08		72.3
Student W	F	NA	Pulled	NA	NA	NA	NA	NA
Student X	F	0	1	6		0		91.7
Student Y	F	4	2	19		0	1	88.3
CLASSROOM Average		**1.25**	**0.71**	7.13	**0.08**	**8.13**	**0.33**	84.9



Appendix J

5th Grade Mathematics Participation Survey Results												
Date of Survey: March 11, 2010												
Total Students Present: 24												
Total Boys: 10												
Total Girls: 14												
Student	**Gender**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL SCORE**
Student A	M	4	4	3	4	4	4	4	2	3	3	0.83
Student B	F	3	4	4	3	4	4	4	2	2	3	0.78
Student C	F	4	3	4	1	4	2	4	3	4	2	0.65
Student D	F	3	2	3	2	2	4	2	2	3	3	0.88
Student E	M	4	3	3	4	4	4	4	3	3	3	0.68
Student F	F	3	2	3	3	4	2	2	2	2	4	0.83
Student G	M	4	3	2	4	3	4	4	2	3	4	0.83
Student H	M	4	3	3	4	4	4	4	3	2	2	0.85
Student I	F	4	4	3	3	4	4	4	3	2	3	0.7
Student J	M	4	3	4	2	4	2	2	1	2	4	0.78
Student K	M	3	2	4	2	4	4	2	3	3	4	0.9
Student L	M	4	4	4	3	4	4	4	4	3	2	0.73
Student M	F	4	3	4	2	3	4	3	2	1	3	0.83
Student N	F	3	3	4	3	3	3	4	3	3	4	0.75
Student O	F	4	4	4	3	3	3	3	2	2	2	0.78
Student P	M	3	2	3	2	4	4	4	2	3	4	0.55
Student Q	M	3	1	4	2	3	2	1	2	1	3	0.78
Student R	F	3	3	4	3	3	4	4	2	2	3	0.95
Student S	F	4	3	4	4	4	4	4	4	3	4	0.65
Student T	F	4	3	2	4	1	4	3	3	1	1	0.8
Student U	F	4	2	4	3	4	4	3	2	3	3	0.78
Student V	M	3	4	3	3	4	3	2	2	3	4	0
Student W	F	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Student X	F	4	3	3	4	3	3	4	2	2	4	0.9
Student Y	F	4	3	4	4	3	4	4	2	4	4	0.78
CLASSROOM AVERAGES		**3.63**	**2.96**	**3.46**	**3**	**3.46**	**3.5**	**3.29**	**2.42**	**2.5**	**3.17**	**0.75**
CLASSROOM MODE		**4**	**3**	**4**	**3**	**4**	**4**	**4**	**2**	**3**	**4**	**0.78**

Appendix K

5th Grade Mathematics Participation						
Lesson Averages						
Total Students: 24	Total Percent of Responses Lecture	20.03%	Total Percent of Responses Inquiry	14.02%		
Total Boys: 10	Total Percent of Questions Lecture	2.12%	Total Percent of Questions Inquiry	7.94%		
Total Girls: 14	Total Percent of Off Task Lecture	2.12%	Total Percent of Off Task Inquiry	0.93%		
Total Participation Increase from Lecture to Inquiry: 11	Total Percent of Raised Hands Lecture	81.27%	Total Percent of Raised Hands Inquiry	79.91%		
Total Participation Decrease from Lecture to Inquiry: 13						

Student	Gender	03/03/10	03/11/10	03/15/10	Lecture Av	Total Overall Percent	03/28/10	04/21/10	04/28/10	Inquiry Av	Total Overall Percent
Student A	M	9	6	2	5.7	2.68%	2	5	0	3.50	3.27%
Student B	F	6	5	9	6.7	3.15%	3	1	0	2.00	1.87%
Student C	F	11	11	10	10.7	5.05%	8	9	0	8.50	7.94%
Student D	F	9	9	0	6.0	2.84%	1	2	0	1.50	1.40%
Student E	M	6	5	2	4.3	2.05%	0	3	0	1.50	1.40%
Student F	F	10	13	5	9.3	4.42%	7	2	0	4.50	4.21%
Student G	M	17	14	0	10.3	4.89%	9	6	0	7.50	7.01%
Student H	M	11	13	3	9.0	4.26%	11	5	0	8.00	7.48%
Student I	F	11	12	5	9.3	4.42%	8	12	0	10.00	9.35%
Student J	M	2	7	2	3.7	1.74%	0	0	0	0.00	0.00%
Student K	M	7	10	2	6.3	3.00%	0	1	0	0.50	0.47%
Student L	M	12	10	11	11.0	5.21%	8	1	0	4.50	4.21%
Student M	F	10	11	3	8.0	3.79%	9	4	0	6.50	6.07%
Student N	F	4	8	1	4.3	2.05%	0	0	0	0.00	0.00%
Student O	F	2	6	2	3.3	1.58%	4	0	0	2.00	1.87%
Student P	M	4	8	1	4.3	2.05%	4	6	0	5.00	4.67%
Student Q	M	8	7	3	6.0	2.84%	0	2	0	1.00	0.93%
Student R	F	6	4	5	5.0	2.37%	13	11	0	12.00	11.21%
Student S	F	13	17	20	16.7	7.89%	6	2	0	4.00	3.74%
Student T	F	7	13	1	7.0	3.31%	2	2	0	2.00	1.87%
Student U	F	22	16	15	17.7	8.36%	2	3	0	2.50	2.34%
Student V	M	10	10	3	7.7	3.63%	1	7	0	4.00	3.74%
Student W	F	NA	Pulled	NA	NA	NA	NA	NA	NA	NA	NA
Student X	F	30	18	21	23.0	10.88%	4	3	0	3.50	3.27%
Student Y	F	16	14	18	16.0	7.57%	7	18	0	12.50	11.68%
CLASSROOM TOTALS		10.13	9.71	6	8.8	4.17%	4.5	4.38	0	4.46	4.17%

Appendix L

5th Grade Mathematics Math Learning Preferences Survey Results									
Date of Survey: April 28,2010									
Total Students Present: 24									
Total Boys: 10									
Total Girls: 14									
Student	**Gender**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Student A	M	3	2	3	3	3	3	3	3
Student B	F	3	2	4	0	4	2	3	3
Student C	F	4	3	4	0	3	0	3	4
Student D	F	3	2	4	0	4	0	2	4
Student E	M	0	0	0	2	0	2	0	3
Student F	F	0	3	4	3	3	3	0	3
Student G	M	3	3	3	2	3	2	0	3
Student H	M	3	4	3	4	3	4	4	4
Student I	F	4	1	4	0	4	0	3	4
Student J	M	3	3	3	0	3	4	0	3
Student K	M	3	0	0	3	3	2	3	3
Student L	M	3	4	4	3	4	0	4	4
Student M	F	0	3	0	3	3	3	3	3
Student N	F								
Student O	F	3	4	0	0	3	3	2	4
Student P	M	0	2	2	2	4	2	0	4
Student Q	M	3	3	3	1	0	1	1	4
Student R	F	3	0	3	4	0	3	3	4
Student S	F	3	3	4	3	4	3	3	4
Student T	F	3	4	3	4	3	4	3	4
Student U	F	3	4	4	4	3	4	4	3
Student V	M	4	4	3	0	3	3	0	0
Student W	F	NA	NA	NA	NA	NA	NA	NA	NA
Student X	F	3	4	0	0	3	0	4	3
Student Y	F	4	3	4	1	4	1	0	4
CLASSROOM AVERAGES		**2.54**	**2.54**	**2.58**	**1.75**	**2.79**	**2.04**	**2**	**3.25**
CLASSROOM MODE		**3**	**3**	**4**	**0**	**3**	**3 & 2**	**3**	**4**