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Project Based Instruction in a Sixth Grade Mathematics Classroom:  
A Case of Roller Coasters

Abstract
In this action research study of a sixth grade mathematics classroom, I investigated how using project based instruction combined with collaborative learning influenced students’ attitudes and beliefs in learning mathematics. I discovered that using a project based approach to instruction helped the students see connections to math and the real world. They felt that math became something exciting instead of just lessons from a book. I also found that most students preferred to work in small groups because they had come to count on their peers for support. They felt that they were more comfortable asking their peers questions in a small-group setting than asking questions in a traditional classroom setting. Through this project based instruction, it also was found that classroom engagement increased when student interest was combined with a variety of challenging and authentic problem-solving tasks. Finally, this action research supports collaborative learning in the mathematics classroom because when children work together it leads to higher self-confidence and positive attitudes.
Introduction

The topic of my research paper was centered on students’ attitudes and motivation in learning mathematics. I had been interested in helping my sixth grade students strengthen their beliefs in themselves as “little mathematicians” in order for them to become more motivated learners.

I have taught at my present school for 19 years. The first five years I was in charge of the K-8 Title I program, and the past 14 years I have been teaching sixth grade. It is a K-12, Class D school system located in Northeast Nebraska. There were approximately 21 certified staff members and 18 classified staff members, as well as 195 students. I am responsible for teaching all core subjects including mathematics, science, and language arts for the sixth grade students. The demographics of my students included 13% diversity and approximately 62% free and reduced status. Our school does not have a program for high-ability students. Students who qualify for Title I assistance in mathematics receive help in grades K-3 only, as the focus in our school this year is reading, so the staff has focused on that area. Therefore, the academic abilities exhibited in my classroom varied.

My general idea for an area of focus was: How can I improve students’ attitudes toward mathematics while at the same time increasing their beliefs in themselves as little mathematicians? Based on my experiences of teaching mathematics, students’ beliefs in their abilities in mathematics greatly influenced their performance. Every year I saw students who had a preconceived notion that they were “bad” at math, were content to get lower grades, and began to fail to put in any effort based on the premise that they hated math and were never going to be good at it. I could relate to these students because I did not have great confidence in myself in
doing mathematics. Before embarking in the Math in the Middle (MIM) adventure, I would often just give up on a problem because “I’m just not good at math.” Because of this self-fulfilling prophecy, I realized that I missed many great opportunities because I was afraid of taking on the challenges that math classes held for me in high school and college, and I did not want this to happen to my students.

After I participated in the MIM project, my classroom teaching changed. It became a common practice for me to engage my students in more problem-solving activities. Beginning last year, problem-solving sessions occurred one class period twice a month. Students were grouped randomly, with the groups changing weekly. Students then presented their solutions to the class. This new teaching strategy started out shaky, but the students soon realized this part of math class would be permanent, and I could see that they began to discuss the problems with their peers and became excited to share their solutions. However, this excitement did not continue when we returned to the traditional math lessons. My primary focus was making sure the students were engaged in instruction that met the district’s curriculum goals and all online testing was completed.

I spent a lot of time reflecting on my role within the classroom. I realized that on the days I did not do the problem solving, I did not allow students to work together or to discuss the work as a whole group. I just presented the lesson, gave examples, and then I spent the rest of the time trying to get to all the students with raised hands to answer all their questions. I was not even giving them time to try to think about the problems; I was just worried about getting them through the material and being successful on the district assessments. I saw the problem solving twice a month as a separate entity from the math curriculum, and the rest of the days were spent
on traditional math instruction with the interaction mostly between teacher and student, with very little student to student interaction.

With that in mind, I began to look back at my general goal. How could I guide students to realize that math was part of a bigger “picture” and not just another class that gave homework that ended with a grade on a report card? We told them that they would need math every day, but I didn’t think that they saw that yet, so if we could find ways to show they how math was used every day in the “real” world, their perceptions might change. Would their attitude and beliefs about mathematics improve if I could change my teaching to show students how math connects to other subject areas and the “real” world around them?

In order to investigate the above questions, I conducted this research project centering on project based instruction. This instructional approach incorporated problem solving, small group learning and journaling into the learning process. Blumenfeld, Soloway, Marx, Krajcik, Guzdial, and Palinscar (1999), in their study at the University of Michigan, found that a teacher needs to combine student interest with challenging and authentic problem solving task in order to increase classroom engagement. Therefore, as I began to look for ideas for a topic that I could center math and science concepts on, I searched for ideas that would be interesting to sixth grade students and yet could be incorporated into the current math curriculum. This ended up with a topic on Roller Coasters. Not only would it address our math curriculum outcomes of Geometry and Measures of Central Tendency, but I saw ways to also incorporate Physical Science with Newton’s Laws of Motion and Language Arts with writing a business letter and giving presentations.
Problem of Practice

I chose to change my teaching practices to show students how mathematics was used in the real world, and I wanted to find strategies to show them how mathematics connects to other subject areas as well. Since I had the sixth grade students for all core subjects, I had the opportunity to use project based mathematics and incorporate science and some language arts without the time constraints of having to coordinate these lessons with other instructors. I expected to find a way for students to see real-world uses for mathematics concepts, thus helping them improve their attitudes toward mathematics and gain confidence in their mathematical abilities.

Project based mathematics supports the National Council of Teachers of Mathematics [NCTM] (2000) Principle of Learning. By working together in small groups, and building on prior knowledge, the students will begin to construct new knowledge. In this project, using what they already know about roller coasters, students will research roller coaster designs across the United States and investigate what makes roller coasters thrilling: speed, duration, angle of drop, height, type of coaster, restraining devices, environment, etc. Technology is an important tool as students collect data on various roller coasters by searching the Internet. By accessing an interactive Web site, the students will do experiments with their roller coaster designs.

During this action research project, two NCTM (2000) Process Standards (Problem Solving and Connections) will be addressed. Students will demonstrate their ability to analyze data that they collect about scientific and mathematical concepts when they develop their own roller coaster. The goal is to design a roller coaster with the most thrilling ride possible while also incorporating specific guidelines, so the students will need to decide which roller coaster design would meet these criteria. During this project, connections also will be made to science
and language arts. Students will apply mathematics to context outside of the textbook and through the use of real-life situations, students will see how these concepts interconnect and build on one another.

The ideal classroom is a community of learners who are excited, actively engaged, and able to communicate clearly their ideas in mathematics. The students also should see connections to mathematics with other core subjects as well as connections to the world around them, and should be provided with consistent opportunities to experience these connections.

**Literature Review**

At the heart of my teaching philosophy lies the belief that a students’ attitude toward school reflects their belief in their academic abilities. If students do not believe they are good at math, they are not as motivated to put forth effort. But when do students begin to develop a negative attitude toward their ability in math? Kloosterman and Clapp (1994) conducted a study examining students’ beliefs about learning mathematics. They found first graders tested seemed to be overconfident and had high expectations of their academic abilities. By second and third grade, children begin to realize that some students learn more quickly and that not everyone will be the high achievers. Do students put forth effort if they feel that they are not capable of achieving the high scores? How do educators begin to change these preconceived notions when they seem to begin to develop as soon as second and third grade?

Lepper (1988) explored design principles for promoting motivation for instructional activities. This research suggested that providing students with continuously challenging activities and feedback regarding accomplishments could increase student interest and self-esteem. Suggestions were given for teachers to present problems of interest to students while making sure the activity provided goals appropriate for students at different levels of
accomplishment. The NCTM’s (2000) Professional Standards for Teaching Mathematics, supported Lepper’s view of providing worthwhile mathematical tasks that are based on the knowledge of the students’ understandings, interests, and experiences. Van De Wall (2007) in his discussion of the 2000 NCTM Standards also encouraged providing math concepts based on students’ interests. By increasing students’ confidence in their abilities, students’ attitudes and perceptions may begin to change and they may begin to see themselves as being capable mathematicians. Educators must find ways to provide worthwhile mathematical tasks that challenge students and build their confidence.

In this study, I explored how project-based mathematics instruction may influence students’ attitudes and motivation, class engagement, and student achievement among sixth grade students. In order to provide background of this study, I reviewed four areas of literature below: project based learning, student collaboration, student attitude and motivation, and student achievement.

**Project Based Learning**

Recent efforts to reform mathematics instruction can be found in the NCTM Learning Principles (2000), which advocated that students must learn with understanding. To accomplish this, students must construct the new knowledge based on prior learning through active engagement. One way to approach these goals is to use project based learning, which is designed to involve students in projects with real-world applications (Teaching Today, 2005).

Blumenfeld et al. (1991) introduced project based learning and the benefits of using long-term projects as part of classroom learning. The researchers viewed project based learning as an instructional method that engaged students in investigation. Within this framework, students pursue solutions to problems by asking and refining questions, debating ideas, making
predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, and communicating their ideas to others. Students may be assigned projects to work on as individuals, small groups, or a combination of both. As these researchers stated, “There are two essential components of projects: They require a question or problem that serves to organize and drive activities: and these activities result in a series of artifacts, or products, that culminate in a final product that addresses the driving question.” (p.371). They explained that teachers using this method needed to be able to create environments that would promote inquiry and risk-taking and emphasize student learning as well as understand project content. Based on the studies of fourth and fifth grade students in Michigan, these researchers found that project based learning was a valuable, yet challenging means of teaching and learning, which could increase classroom engagement and student interest because they involved students in solving authentic problems, in working with others, and in building real solutions.

In another study, Meyer, Turner, and Spencer (1997) examined project based learning with fifth and sixth grade classes. The focus of their study was to examine how a project based learning environment would affect student motivation. Qualitative and quantitative data from five aspects were collected: academic risk taking, achievement goals, self-efficacy, volition, and affect. The findings indicated students’ affective reactions to difficulty and failure seemed to have either supported or disabled their persistence in problem solving in important ways. The researchers concluded that collaboration could support students trying out ideas, learning from their mistakes, and staying motivated to finish the project. According to these researchers, teachers should follow three suggestions if they want to establish and support an environment where students feel comfortable to take risks:

1. Provide time to discuss various approaches to problem solving.
2. Provide opportunities for students to describe their mistakes or dead-ends and discuss what they learned from them or have their peers suggest possible solutions.

3. Foster an improvement-versus-a completion focused approach to a project by having students develop a rubric for critiquing their own or a partner’s work (p. 518).

Any instructional approach has to be balanced to avoid potential downfalls. Both Blumenfeld et al. (1991) and Meyer et al. (1997) agreed in their findings that project based instruction provided challenging school activities. Participating in challenging activities gives students the opportunities to gain knowledge, cognitive strategies, and feelings of increased confidence. However, like other academic challenges, projects also have the potential to frustrate students and to send them to search for alternative paths. Students who want to avoid projects may work too quickly or simply not work at all (Meyer et al., 1997).

Civil (2002) conducted a study in a fifth grade classroom involved in a mathematics teaching innovation that attempted to combine everyday mathematics, mathematicians’ mathematics, and school mathematics. The approach required considerable risk-taking on the part of the students. The instructors had to tackle the issues of copying and competition versus cooperating, and they also had to work on building an atmosphere in which being wrong was seen as something valuable in a route toward learning. Civil stated, “In a classroom emphasizing mathematicians’ mathematics, students would spend time exploring problems. The work of most mathematicians is certainly characterized by the investment of time and persistence in working on a problem. Hence, although the proposed tasks may be mathematically rich, unless we engage the students in spending time exploring and reflecting, they may be missing the point” (p.59).

The results of the data showed that in some activities children were driven by performance values in that their goal was to get the answers correct. In other activities, personal
and social values were more important in that students were more concerned how their groups were formed and what their peers thought about them. Yet, in other activities, students seemed genuinely interested in the mathematical value in that they appeared eager to understand the mathematical concepts and principles behind the tasks and were eager to explore challenging problems.

The above research (Blumenfeld et al., 1991; Civil, 2002; Meyer et al, 1997) indicated the benefits of using a project based method of instruction with middle level students. These studies also agreed that project based learning demands a high degree of risk-taking by the students. Consequently, a project cannot just be assigned to students without proper instruction and setting the stage beforehand. Like all instructional approaches there is the potential for misapplication.

**Student Collaboration**

As previously mentioned, project-based learning could integrate with either individual or small group work methods (Blumenfeld, et al., 1991). My action research incorporated the latter because student collaboration had been recommended as an important resource for learning. Mueller and Flemming (2001) characterized collaborative learning as a process in which “knowledge is not transferred from expert to learner, but created and located in the learning environment” (p. 261). Their ethnographic case study followed a sixth and seventh grade combination classroom through a five-week project. The researchers found that when working together in cooperative groups, students required periods of unstructured time to organize themselves and to learn to work together toward a mutual goal.

The small group learning method provides opportunities for students to construct explanations for underlying principles for solving problems. This method is a powerful setting
for facilitating students’ exchange of explanations. It can also serve as a research tool for investigating students’ preferences regarding problem-solving strategies and other cognitive activities (Leikin & Zaslavsky, 1997). The overriding message from students is that small group learning, rather than passive listening, reading, or note taking, draws them into subjects and deepens their understanding and appreciation of what they are learning (Ares & Gorrell, 2002).

Before student collaboration can be implemented in the classroom, teachers must be aware that it is not simply grouping students to work on an activity. Slavin, Leavey, and Madden (1984) pointed out students of all levels of performance should work together in structured groups toward a shared or common goal. Rather than working as individuals in competition with every other individual in the classroom, students are given the responsibility of creating a learning community where all students participate in meaningful ways. Slavin’s (1991) research revealed that students completing small group learning group tasks tend to have higher academic test scores, higher self-esteem, and greater comprehension of the content and skills they are studying.

Leikin and Zaslavsky (1997) conducted a quasi-experimental study on the effects of different types of students’ interactions while learning mathematics in a small group setting. The findings for the small group settings indicated an increase in students’ activeness, a shift toward students’ on-task verbal interactions, and positive attitudes toward the small group learning method. They also found there can be problems with student collaboration. High achievers running the groups, shy students remaining passive and aggressive students controlling the ideas of the group are all problems that teachers must be aware of when implementing this strategy.

Student collaboration at the middle school level is challenging according to Eccles et al. (1993). At this level, schools are more concerned with academic achievement than social skills.
Eccles et al. stated that traditional middle schools are usually larger, less personal, and more formal than self-contained elementary classrooms. Middle schools often have different teachers for each subject period with the students moving from room to room.

The researchers in all these studies agreed that when children work together it leads to higher self-confidence and positive attitudes. Ryan and Patrick (2001) found that prior motivation and engagement were found to be strong predictors of subsequent motivation and engagement. The use of collaborative learning in my action research project offered students the opportunity to engage in activities to help them gain confidence in themselves.

**Attitude and Motivation**

Research showed that motivation and attitude toward mathematics declined significantly between sixth and seventh grade (Eccles et al., 1993; Ryan, 2001). Eccles et al. (1993) conducted a comprehensive longitudinal study with 2,500 seventh grade students to address whether students’ ability, beliefs, and achievement values changed as they made the transition from elementary to middle grade schools. Results of this study indicated that students’ attitudes and motivation toward academics declined during this transition period. The authors stated that the declines observed in students’ motivation in middle school could be related to the fact that middle school mathematics teachers, in comparison to elementary school teachers, controlled students more, provided them with fewer decision making opportunities and felt less efficacious.

Another possible reason for students’ declined motivation may be due in part to the nature of peer group influence. Ryan (2001) used social network analysis and investigated student motivation focusing on peer groups of adolescents in middle school. It was found that students’ motivation decreased from the fall to spring of their first year. Students who viewed themselves as being successful or as failures in school were observed to spend time with other
students who shared the same view. As a result, the researchers concluded that it is difficult to motivate students who think they have no chance of being successful because they have a social network built up to support their belief. The above literature guided my project (project based learning integrated with peer cooperation) in constantly monitoring groups and purposefully moving them into new social networks during the process of the project to help increase their confidence and motivation.

In another study, Ryan and Patrick (2001) investigated how students’ perceptions of their social environment related to changes in motivation and engagement when they progressed from seventh to eighth grade. Prior motivation and engagement were found to be strong predictors of subsequent motivation and engagement. Students’ perceptions of teacher provision of support and mutual respect were related to positive changes in their attitude. Based on these data, the researchers concluded that a student’s attitude and motivation are formed from a number of influences. A teacher cannot just blame a student’s low motivation on a “bad” attitude. The student’s teachers, peers, and the student himself/herself all play a significant role in forming attitude and motivation.

The National Research Council (2001) discussed the role of productive disposition which is related to student motivation:

Productive disposition refers to the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics. (p. 131)

While motivation can come from different sources, productive disposition must come from the learner. If a student was extrinsically motivated, he/she would perform for a reward such as grade, acceptance by peers, or something tangible. In contrast, if a student was
intrinsically motivated, he would learn in the sake of learning itself and would believe that learning mathematics was useful and worthwhile (Lepper 1988). Intrinsic motivation and productive disposition are similar. The more mathematics students understood, the more sense it made to them. According to Lepper, when students seldom were given challenging mathematical problems to solve, they began to expect that memorizing rather than making sense was what mathematics was all about. They then began to lose confidence in themselves as learners. In contrast, if students began to see themselves as able to learn math and use it effectively, they were more likely to look for challenging situations and learn from them. Slavin (1991) agreed with the previous studies that stated that children entered school with positive attitudes toward mathematics. These researchers pointed out students’ attitudes began to turn negative quickly if they began to see themselves as poor learners when that view was associated with the teacher’s view of mathematics. When students begin to perceive themselves as poor learners, that negative attitude toward mathematics can become something more intense, often causing students’ math anxiety (Ma, 1999).

In order for student motivation to have a positive influence on achievement, a teacher must address this issue in planning lessons. Middleton and Spanias (1999) focused their study on a collection of research on student motivation and achievement in mathematics. The researchers discussed the ways in which teachers attempted to build student motivation into their lessons. They also looked into the belief systems of teachers compared to those of their students. Middleton and Spanias stressed the importance of the need for teachers to be aware of their students’ beliefs and attitudes and to use that knowledge to adjust their mathematics instruction. They uncovered two important issues about student motivation in mathematics. First, their research indicated that success in mathematics was a powerful influence on the motivation to
achieve. Second, the students’ ability to achieve success in mathematics could be built into the mathematics classroom. When students saw themselves as capable of doing well in mathematics, they valued mathematics more than students who did not see themselves as capable of doing well. The researchers suggested that motivational patterns were learned and that students generally learned to dislike mathematics and that this dislike becomes an integral part of their mathematical self-concept. Motivations are seen as incentives for performing a behavior. They may be intrinsic – learning for the sake of learning, or they may be extrinsic – engaging in academic tasks to obtain rewards.

Lepper’s (1998) findings agreed with those of Middleton and Spanias (1999). He stated that when children are motivated intrinsically to perform an academic activity, they spend more time engaged in the activity, learn better, and enjoy the activity more than when they are extrinsically motivated. According to Lepper, traditional teaching, however, focused on memorization of skills and getting the “right” answer. Students relied on the teacher to tell them if their answer was correct. Only a few children were good at memorizing the rules and thrived on receiving the good grades. The traditional system rewards the learning of rules but offers little opportunity to actually do mathematics (Van De Walle, 2007).

The previous studies highlight the importance of students’ motivation and alert administrators and teachers with possible declined student motivation in middle grades. My action research focused on sixth graders’ motivation and attitude toward mathematics, which is an urgent issue in education today. Unlike the previous studies, I used a project based learning approach to investigate ways of enhancing students’ motivation. This approach offered a positive social network by allowing students to do more small-group work. This approach was likely to develop students’ intrinsic motivation.
**Student Achievement**

It is impossible to examine student attitude, motivation, and student participation in mathematics without considering student achievement. Regarding the study of student achievement, all factors must be analyzed together to get a true picture.

According to the National Research Council (2001), mathematical proficiency has five components or strands: Conceptual Understanding, Procedural Fluency, Strategic Competence, Adaptive Reasoning, and Productive Disposition. These strands are interwoven and cannot be independent of one another. Students need to work on each of these areas to develop strength in order to achieve mathematical successes. Mathematical successes are defined as gaining mathematical knowledge. If schools do not offer the students opportunities to develop each of these strands, then mathematical proficiency will be difficult to achieve (Kilpatrick, Swafford, and Findell, 2001). Project based instruction provides the opportunities for students to address each of these components. Students will develop comprehension of mathematical concepts, operations, and relations. They will be engaged in activities that provide opportunities for students to develop logical thought, reflection, explanation, and justification, and they will see mathematics as sensible, worthwhile and useful.

Xin Ma (1999) examined various factors in a meta-analysis involving 26 studies on the relationship between attitude toward mathematics and achievement in mathematics among elementary and secondary students. This researcher found that a leading factor in student attitude was mathematics anxiety. If a student does not feel comfortable performing a task, there will be no motivation to get it completed. However, no specific link between motivation and achievement was found in this study.
Koller, Baumert, and Schnabel (2001) also studied the correlation between motivation and achievement. They conducted a study involving 602 seventh, tenth, and twelfth grade students. The researchers found that motivational factors are of special importance for successful learning processes. Their data showed that although academic motivation did not influence student achievement, it did directly affect their course choices. Therefore, when students are motivated and feel successful in mathematics courses, they will opt for more advanced courses in upper secondary schools and college.

Kloosterman and Cougan (1994) found similar results when they studied the mathematical beliefs and achievement of students in grades kindergarten through sixth grade in a school where teachers were participating in a project to improve mathematics teaching. The researchers relied on test scores and evidence of mathematical knowledge to determine student achievement. The results of their study showed that those students who were confident in their ability in mathematics and who believed it was useful had higher achievement than those who were not confident and did not believe it was useful. When students see examples of the utility of mathematics, they tend to believe it is useful and actively work to learn it (Meyer, et al., 1997). One way to approach this goal is through project based mathematics, which is designed to involve students in investigations of authentic problems (Blumenfeld, et al., 1991). When projects are cognitively complex they have the potential to help students learn because they must represent knowledge in a variety of ways and pose and solve real problems.

**This Study**

While Meyer et al. (1997) studied fifth and sixth grade students during project based mathematics, my focus was on my sixth grade students and the project combined mathematics, science, and language arts. Previous studies were conducted from researchers’ perspectives while
I was both the researcher and the teacher in this action research. I used advice from Blumenfeld et al. (1991) regarding the components necessary for success with project based learning.

My study examined project based learning combining mathematics, science, and language arts to determine the impact it may have on students’ attitudes, class engagement, motivation and achievement. My study contributed to this field in several ways. First, my project incorporated collaborative small group work, which exposed students to alternative solution methods. None of the research I found related this use of student collaboration in a cross-curricular project based curriculum. Second, through this research, I was able to examine changes in student attitude, motivation, engagement and achievement. Third, because this method of instruction engages students in applications of mathematics which may help them transfer skills to other disciplines and real-world problems, I chose to combine the disciplines of science and language arts with mathematics. Since I am the instructor of these three subjects, this gave me a more flexible time frame throughout the day and did not just limit me to the 50-minute period set aside for mathematics.

Previous studies (Ares, Gorrell 2002, Blumenfeld, et al 1991, Meyer, et al 1997, Slavin, et al 1984) provide a basis for my action research. I took advice from Meyer, Turner, and Spencer (1977) when they discussed the challenges when implementing project based learning. Although I had assigned many projects to my classes over the years, I realized after reading the literature the activities I did with my students were simply to group them together to complete a task. I had not ever taught the students how to work together, and I always just assumed that they should know how. Based on the guidance of previous studies (e.g., Ares, Gorrell 2002, Blumenfeld, et al 1992, Meyer, et al 1997, Salvin et al 1984), I began my action research with instructing the students on their individual roles and responsibilities when working in
collaborative groups. I educated students about how to collaborate with their peers. I attempted to avoid the problems of having high achievers run the groups, of having shy students remain passive, and of having aggressive students control the ideas. My project required students to work individually at times and then bring their work with them to the group to discuss. Because we had spent time working on equal sharing of ideas and mutual respect (Slavin 1991) from and to all group members, the students began to feel that they all had important ideas to share. After several lessons and modeling, the students were ready to apply this to project based mathematics.

Purpose Statement

The purpose of my study was to determine the changes in students’ attitude, motivation and achievement when participating in project based mathematics. This was important to my own teaching because it would provide me with an opportunity to explore a project based approach to teaching mathematics. The data gathered during this research project would help me determine if project based mathematics was a productive supplement.

The new method used during this project was small group learning incorporated with cross-curricular project-based instruction. I was interested to see how the students valued the importance of this type of instructional approach and how this new teaching method changed students’ attitudes and behaviors toward mathematics. There were three main research questions that guided me through this process. The first question focused on the understanding of my own teaching, while the other two questions focused on student attitudes, behaviors, and achievements in the area of mathematics.

1. What does my teaching look like when I implement project based instruction in my sixth grade mathematics class?
2. What will happen to students’ motivation and their attitudes toward mathematics when
participating in project based instruction?

3. How do students’ participation and mathematics achievement change when participating in project based instruction with student collaboration?

**Method**

As I previously mentioned, I modified previous research ideas and methods and incorporated them into my project. One thing worthy of mentioning is about the term “cooperative learning.” For the purpose of convenience, students and I used the phrase “cooperative learning” during this project which was intended for “student collaboration” involved to project based learning in my action research. Thus, the two terms “cooperative learning” and “student collaboration” are interchangeable in this study.

To begin my research project, I spent from February 3-14 working on student cooperation strategies with the students. The class was divided into four collaborative groups. I selected the groups because I wanted mixed abilities in each group, and I also wanted to split up some cliques that had developed in the classroom. I chose teaching strategies and activities from E.G. Cohen’s book, *Designing Groupwork: Strategies for the Heterogeneous Classroom*. During selected activities, we worked on improving group processing skills and focused on recognizing constructive and destructive behaviors. Constructive behaviors are ways that help to get the group’s work done. A skillful group member should have the following features: (a) has a new idea, (b) requests or provides information, (c) puts ideas together, and (d) asks if everyone is ready to decide what to do.

Destructive behaviors are common problems that arise in groups and often result in hurt feelings and a poor group product. A destructive group member could show signs of the following: (a) talks too much, (b) listens very little, (c) insists on having his or her ideas
accepted, (d) fails to do something about the destructive behaviors of others, (e) criticizes people rather than their ideas, and (f) lets other people do the work. Through the use of these strategies, I tried to establish cooperative learning groups which would enhance student confidence and increase student learning.

Prior to February 3, I set up a project timeline (see Appendix A). I put this in a binder, along with necessary worksheets, assessments, rubrics and questionnaires that I would need for the project. This kept me on track and organized. The initial data I collected was an attitude survey (see Appendix B) to determine individuals’ beliefs and attitudes toward mathematics. I administered this to all the students at the beginning and end of the project. I asked students to respond honestly on these and assured them that their answers would not affect their grade, nor in any way would affect my perceptions of them.

I also started keeping a journal of observations and reflections during my research. At first I wrote weekly, sometimes just jotting down brief notes. I found that the more time I took to write in my journal and describe observations in detail, the easier it was for me to analyze at a later date because I did not have to rely on memory for crucial information. So I began to try to write daily including everything I thought might be important when it came time to gather my information. These journal entries sometimes captured exact words from students’ written or oral communication. Other times the entries centered on observations I made about students’ interactions with one another within their peer groups or individual work, and yet other times the entries reflected my teaching in regards to classroom management, instruction, or my changing role in the classroom with this new approach.

A vital source of data throughout this study was interviews. I interviewed five students individually at the beginning and the end of my research. One objective of the interviews was to
determine students’ attitudes about collaborative group work incorporated with cross-curricular project based instruction. The other objective was to determine students’ attitudes and their perceptions about their abilities toward mathematics. The Pre-Project Interview and Post-Project Interview questions (see Appendices C and D) differed slightly in order to record students’ feelings before and after the project. The questions focused on collaborative groups and asked students what they liked about working in groups, what made working in groups difficult, how they preferred the groups be chosen and why, and how students determine if their group is communicating well.

Another source of data was my grade book. It contained a record of students’ grades for pre-test and post-test data for mathematics and science concepts that were taught during this research project as well as homework scores and scores for the language arts assignments (see Appendices E, F, and G). The students each had a separate folder to keep all materials related to this project. Students also responded weekly to Journal Questions (see Appendix H), which focused on students’ attitudes and perceptions toward mathematics. The questions asked the students to respond to their feelings about their success in math class, what they wished math class would be like and why, interest in math class, motivation toward project based mathematics, and feelings about cooperative groups. Students also completed a Cooperative Learning Student Questionnaire (see Appendix I) after specified group activities. They were able to make comments as to how much each student contributed to the finished project, and how well each student respected the opinions of the others in the group. I then completed the same rubric for each student based on written data from observations I made in my journal on how the students interacted with members of their group during assigned activities. I used a chart to analyze changes in students’ responses.
I analyzed my data based on three research questions. With regard to the first question on changes in my teaching, I used my journals first. I examined each of my entries and looked for evidence that changes had taken place. After that I looked at students’ responses to their journal questions and the interviews to look for any evidence that changes had occurred in my teaching. Regarding the second question on student motivation and attitude, I looked first at the pre- and post-surveys and made a chart to look at changes in students’ responses during project based instruction. Then I looked at the students’ responses in their journals and interviews for any responses that dealt with changes in attitude and motivation and wrote a master list of their comments again looking for common themes among the students. For my last research question dealing with changes in participation and achievement of students when participating in project based learning with student collaboration, I looked first at test data and students’ daily grades obtained during the research period. I compared pre- and post-test scores to measure students’ growth. Using just this data along with classroom grades, it was not possible to show that students would not have gained as much or more with another teaching method. I did not have enough collection instruments to measure achievement. I then focused on students’ journal responses and their interviews to look for data regarding how students felt collaborative group work contributed to success in mathematics.

Findings

Before presenting my findings of this project, I first describe my average teaching day, which will situate my stories to be shared. My sixth grade mathematics class is held on Monday, Tuesday, and Friday afternoons for 40 minutes, and Wednesday and Thursday afternoons for 60 minutes. Because I teach all the sixth grade core subjects, I have some flexibility, so often times if I knew ahead of time that a student would be absent in the afternoon, we would have math
class in the morning. I have 15 students, but one student attends Special Education Math classes and one came into the school district in the middle of the research period, so for the purpose of this study, I have included data from 13 students.

Before my involvement in MIM, my “average” teaching day would begin with instruction of a lesson from the book, followed by examples, then an assignment. Our district used the Silver Burdett Ginn Mathematics Series, and even though it did include problem solving, I often skipped those lessons because of my insecurities with mathematical concepts. In addition to this, our school used the Accelerated Mathematics (AM) program as a supplement to the regular curriculum, so students were assigned AM objectives, which were a combination of basic skills and critical thinking to work on during their study time. This program involved pre-testing students at the beginning of the year and then setting them up on the computer-based program at their mathematical level. Other than the few critical thinking problems in AM, I did very few “thinking” activities and left out the problem solving or critical thinking lessons from the textbook. I wanted to make sure that all the time was spent teaching the District’s Sixth Grade Curriculum. I rarely used any manipulatives or let students work in partners or groups for math. I rationalized that these took too much time, and I did not feel that the benefits would be worth the loss of time away from learning the basic skills.

After beginning MIM, my math classes began to look different. I assigned, at least twice a month, a Habits of Mind problem that I learned from MIM and adapted for my sixth grade students. As the students worked on these in groups, I began to see students become more independent as they relied on their peers to answer questions about the problems. However, typical everyday instruction remained “traditional.”
This year, I was determined to add even more problem solving to math class. After being immersed in problem-solving activities through MIM, I knew how important it was to engage in critical-thinking activities. These had been lacking from my previous instruction. So this year, three days a week, there was a problem on the easel to solve in their study time, and on the fourth day, the students signed up to present their solutions to the class. This is in addition to the textbook lessons and the AM program. I tried to incorporate a hands-on activity at least twice a month because I saw how beneficial they were to me in the MIM classes I took. I was disappointed in myself when I realized that when time became an issue, such as snow days, spring break, holidays etc., I resorted back to past practices and skipped problem solving while I focused on traditional methods. In doing this, I was inadvertently showing my students that problem solving was just something extra if there is time, but the true importance lay in the book. This was not the message I intended to send.

When choosing my research project, I expected myself to have a totally different approach to teaching mathematics. I was looking for something that would be new to both myself and the students and would not allow me to revert back to “traditional” methods. Project based instruction was found to be an excellent approach to implement in my classroom. This approach provided me an opportunity to plan a cross-curricular unit built around a topic, roller coasters, which would allow me to incorporate math, science, and language arts concepts and also motivate and engage my sixth graders in a deeper mathematical thinking and learning.

Below, I report my research findings based on each of my three research questions.

**My Teaching Changes When I Implement Project Based Instruction**

The first research question explores my own teaching when project based instruction was implemented in the classroom. Looking back at my journal entries, I realized that I was unsure
about spending this much time on a new teaching strategy and worried that students may not perform as well on district assessments using this new approach. In my first week’s journal, dated February 6, I noted,

“After four days of cooperative learning instruction and practice, I can see that this will take a great deal more time than I anticipated before students begin to develop cohesiveness as a learning community. What happens if I spend too much time on this and then don’t have enough time to finish the rest of the research? What happens if this project based approach doesn’t give students enough time and practice on individual math and science skills to pass their assessments? I just have to keep myself focused on why I am making changes in the first place. This will be much better for my students in the end.”

Because this is such a different teaching approach for me, I realize that the uneasiness I was feeling was due largely to the changes that were taking place in my regular routine. During student interviews, a student named Joe¹ explained his feelings toward this new method, “I actually look forward to math now. Before it was like, boring. We sat down, you talked, we did some stuff on the board, then did our assignment. Now we get to talk in our group and discuss stuff. It’s fun, even if we argue sometimes and can’t always agree on the answers right away.”

This was great for me to hear. I didn’t realize what a “rut” I was in with my teaching.

I now found myself as strictly a facilitator in the classroom. Through the use of the project map and binder, all lesson plans, assignments, outlines of activities, and keys were organized and at hand before I began the project, so I was able to stay focused, reasonably on

¹ All students’ names are pseudonyms.
task, and I was well prepared for each day’s lesson. This left me with more time to spend on instructional issues. In my journal on March 2, I wrote,

“As I walked among the groups and listened to the conversations that were taking place throughout the activity today, I realized that with this new approach, I am not worried about getting papers graded to see if the students understood the concepts I taught, I can monitor that immediately by listening to the discussion that is taking place. If a group is straying off course, I can intervene immediately and I do not have to wait until homework is graded to know when understanding has occurred. It also dawned on me that we expect students to listen to us the majority of the day, but when do we take the time to really listen to them? This approach gives me the opportunity to do just that.”

Because students were able to take the new concepts from math and science that they had learned and apply them directly to their roller coaster project design and construction, they seemed to have an easier time mastering the material. This was reinforcement for me that the time spent on project based instruction was worth the effort and the changes in teaching were positive. John explained during the interview, “If we can see what we need to learn this for, it makes it easier to understand.” Obviously, showing students a direct, real-world, practical use for new concepts, there is a direct impact on learning.

During this project, I had to keep reminding myself not to “jump in” when groups had disagreements or when they struggled with what task they needed to get accomplished. If I stayed back and monitored the groups, the majority of the time, they worked out solutions to their problems. Through project based instruction, I have changed my focus on what students need to spend time on during class. The focus was not on memorizing facts and processes but now was on problem solving and critical-thinking skills. By providing the necessary prompts and
guidance when needed, I have found that generally, in all subject areas, students have been asking fewer questions of me and asking more questions of their peers. This has been an exciting change to see them become more independent learners.

Although I was excited to see the changes taking place with the students through project-based mathematics, I was amazed at how quickly I reverted to prior instructional practices when time became an issue. Implementing new instructional strategies to reform one’s traditional classroom teaching was not at all straightforward. In my journal on March 11, I wrote,

“When I had the kids work in their collaborative groups on their roller coaster activities, I saw excitement in their eyes and they were eager to begin class. Then later in the week, because of Spring Break, I became nervous about the time again and I revamped the math lesson for the day. As I looked out at the students, I noticed the spark gone from their eyes, and I realized that, without thinking, I had immediately reverted back to previous traditional practices. The lesson was on geometric shapes, and I had not provided any shapes for them to work with. I didn’t think they would have trouble with the lesson, so I tried to quickly move through it. When I went over their assignments, it was clear that most students had trouble with the lesson, and I should never assume anything.”

When I saw their enthusiasm gone, I asked the students to write in their journals and express how they felt about the day’s lesson. Below are typical responses:

- Today was not fun. I have no idea how I am supposed to figure this out (Joe).
- Today was okay, just boring again (Anna).
- I wish we could work in our groups today. Having someone else explain it to me would make this easier (Eric).
• I think everybody else knew what to do today except me. I’m just dumb at math (Steph).

The following Monday, I redid the lesson, providing shapes for the students to classify and sort. We discussed how geometry related to roller coaster design and found different types of triangles and angles in support structures in roller coasters. Then we played a game and the students redid the assignment from the previous week with no trouble. I was excited to see the learning that had taken place when students were able to make connection to the real world, communicate with their peers, and use hands-on activities.

**Students’ Attitudes and Motivation Toward Mathematics Changes When Participating in Project Based Instruction**

I found that almost all the students liked the idea of project based instruction in place of our traditional math lessons. I explained the entire project to the students before we began so they would have a clear idea of how each component we were studying would fit into the final project. They knew the culminating project would be to construct a model of a roller coaster design. The students, of course, just wanted to jump directly to the project and bypass the work. I had to get them to understand that all the preliminary research was necessary for a successful roller coaster in the end. The interviews I conducted provided supporting opinions toward a new method of instruction. Students were asked during the initial interview, “What, if anything, makes learning and doing math exciting?”

Sally: “I really enjoy projects where you have to get up and do something other than just worksheet or a page in the book. I don’t like it when we do the same thing over and over and do nothing fun. To me it’s very boring.”

Joe: “Doing projects and applying what we’re doing makes it more fun. Also doing
problem solving and actually having to think about it. I don’t like doing things over and over after we’ve already done it a lot even though we know it.”

Anna: “Doing fun stuff. Can you find fun activities to help us learn the hard stuff? That would make it an easier way to get all that stuff that sometimes doesn’t make sense. Math is frustrating when we rush through outcomes and I still don’t know how to do it for homework or tests.”

Nora: “Sometimes I think a project makes math fun, but most of the time it is boring. I don’t like it when teachers put us with partners and you get stuck with someone who just wants the answers or to copy your paper.”

Trent: “Playing games or doing stuff besides worksheets or pages in the book would make math better. I don’t like it when everyone is talking or saying the answers all at once and I don’t understand it. I get confused and upset.”

It was obvious from most of the students’ responses that a new approach was in order. Nora made it clear that just putting students with partners with no clear instructions about how to work together can made it frustrating for students.

When I started this project, I assumed that all my students would prefer this type of instruction in place of “traditional” instruction. I wrote in my journal about the excitement I saw when students were immersed in aspects of this project. On March 24, I asked students to answer the following question in their journals, “Are you more interested in the roller coaster project than our regular math class? Explain why or why not.” Eleven students expressed excitement about this new approach and described in detail the math and science skills they have used when designing their roller coasters. One student, John, explained in his journal,
“I am more interested in this project because math is easier for me to see when we use it with the roller coasters instead of just numbers over and over again. This project is helping me with math skills because we are working with angles, triangles, quadrilaterals. I am also learning Science because this project has taught me that most roller coasters don’t use engines, so we need to learn about things like velocity and momentum.”

Some expressed appreciation for being able to work in cooperative groups for some activities and on their own for other activities. They liked the variation so that class wasn’t the same thing every day. A student, Nora, wrote in her journal,

“I like this project math because it makes me think even though sometimes I’m not very good at it. I like to work in both groups and alone because when you work in a group you can ask someone for help and when you work alone you think harder, which is good for your brain.”

Two students, however, expressed dislike for this type of instruction. They wrote the following in their journals:

Steph: “No, because I don’t like doing projects like this. It makes me very confused because I don’t understand that well and then I’m totally lost. This new math project is not helping me with my math skills, I don’t think, and I’m confused and my brain gets jumbled and I forget everything. I want to have regular math class because I’m afraid I’m going to struggle in seventh grade when we don’t do projects.”

Eric: “I am more interested in regular math. This is a lot harder that it is fun. We have to do a bunch of angles and different supports and have to think about Newton’s Laws, which makes it really hard. I like it better when we just have an assignment
and I take it home and my mom tells me what to put down on my paper because she knows this stuff real good. This is too hard when we have to think and have our work done in school. I’m worried that my math grade will go down and then my mom will be mad.”

From my data collection, I can discern two things. First, generally speaking, my students were more motivated and had a more positive attitude toward mathematics. And the second is that this project made the students “think” and “apply,” which made understanding mathematics principles easier for some students and more difficult for others.

The Level of Students’ Participation and Achievement Changes When Participating in Project-Based Instruction With Student Collaboration

From February 3-11, I taught cooperative learning skills and strategies to the students while they engaged in activities. At the end of week one, I wrote in my journal:

“What really stood out for me this week was the dynamics of the groups as they worked together. The ‘Broken Circle’ activity had to be completed without talking. The students who are used to taking control of a group were forced to be ‘equal’ members and patiently wait for everyone in their group to finish. One student expressed frustration when she wrote in her journal. She said the activity was too hard when you couldn’t talk. Another student, who rarely speaks at all in class, indicated in her journal that she loved the activity and was beginning to feel like an important part of the group. Another student wrote that the activity was frustrating, but the group worked well together and everyone did an equal amount.”

On the Attitude Survey that was administered on February 3 and again on April 22, the students were asked to respond to the statement, “Working in groups helps me understand math.”
Six students indicated ‘Always’ on both the pre- and post-surveys. Two students indicated ‘Sometimes’ on both the pre- and post-surveys. Three students selected ‘Always’ on the pre-survey and selected ‘Sometimes’ on the post-survey, while two students who selected ‘Sometimes’ on their pre-survey selected ‘Always’ on their post-survey. Table 1 illustrated the survey results.

Table 1. *Attitude Survey Data*

<table>
<thead>
<tr>
<th>Working in groups helps me understand math.</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
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<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Student A</td>
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<td>x</td>
<td></td>
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<tr>
<td>Student B</td>
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<td></td>
<td>x</td>
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<tr>
<td>Student C</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Student D</td>
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<td></td>
<td></td>
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<tr>
<td>Student E</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Student F</td>
<td>x</td>
<td></td>
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<tr>
<td>Student G</td>
<td>x</td>
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<tr>
<td>Student H</td>
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<td>x</td>
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<tr>
<td>Student I</td>
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<td>x</td>
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<tr>
<td>Student J</td>
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<tr>
<td>Student K</td>
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<tr>
<td>Student L</td>
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<td></td>
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<tr>
<td>Student M</td>
<td>x</td>
<td></td>
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</tbody>
</table>

This data were consistent with the responses I got from the students in their journals as well as the notes I had written in my journal. Although most students seemed to enjoy working with
their group, there was frustration with some uncooperative group members. Some students indicated in their journals that this contributed to some negative feelings of students toward mathematics, at times, and caused some students to prefer to work independently. With regard to the journal question, “We worked in cooperative groups during this project. Do you like this type of group work or would you rather work on your own? Explain.” Two students shared their concerns:

Erin: “I rather work on my own because I don’t get along with some of the people in my group. It is just easier by yourself so you don’t have to convince other people in your group that your answer is right. Sometimes when someone in your group messes around all the time it’s not fair for the rest of us.”

Mike: “Probably the worst thing I really dislike about group work is being in a group that argues or controls so you can’t help. I think one of the worst things is being in a group or with a partner that doesn’t listen to what you have to say, your reasoning.”

As a teacher and researcher, I also noticed the new challenges brought by the use of collaborative groups. This challenge is possibly due to that collaborative learning goes against our traditional teaching methods where students are expected to sit in their desk, work quietly, and raise their hand when they have a question. I indicated in a March 19 journal entry:

“I had not thought about how to handle a cooperative group assignment when a student is absent. The other problem I encountered this week was during an activity that required students to work individually on researching various roller coasters, then, the following day, the groups were to compile the information and complete an activity using measures of central tendency on their data. What do I do when a student does not finish their part
of the assignment? These situations have caused new frustrations for me, as well as their peers in the group.”

Throughout the course of this research, collaborative learning behaviors were revisited and reinforced. I realize that it will always be a work in progress and that students don’t know “how” to work together collaboratively until they are taught specific behaviors. Indeed, changes in students’ attitudes and participation occurred when using project based learning with student collaboration. According to the students’ journals and the interviews, the students indicated positive feelings toward cooperative learning toward the end of the research period. Three students’ post-interviews summed up the general feeling of the class.

Sally: “I like working in groups because you may be right, but your group members may have an easier or better way to show you and I think it’s good to see other’s points of view on things. I also think that if you’re wrong and they got it right they can explain to you why it’s wrong, not just seeing a checkmark by your answer. Probably the thing I dislike is being in a group that argues or controls you so you can’t help. But we got better and in the end everybody tried to cooperate and listen to the rest.”

Nora: “I like working in groups because I learned different ways to do stuff. I know I have issues, like I try to take over everything, but I have learned to control it better and let others voice their opinions. I also have learned that what I think isn’t always right and that I am wrong sometimes. Overall I like working in groups.”

Trent: “I like working in cooperative groups because you have at least two or more brains that all have different ideas and usually at least one of those ideas or
answers is right. I don’t like always working alone because if you don’t understand it then you only have your brain to figure it out.”

Initially, I was concerned about students’ achievement using project based instruction integrated with student collaboration. There are several different ways to handle grading issues with the group assigned tasks in this project. I chose to grade students individually on tests. I did not give a group test grade. I used a group grade for students on activities that were assigned as a cooperative group, and I used individual grades for those activities that students were to complete on their own. It is impossible to compare achievement of the concepts taught in this research from project based mathematics and traditional mathematics methods because I was not able to teach the same concepts using different methods in two different sixth grade classes. The pre-tests were administered before any instruction had taken place, and the post-tests were administered after the instruction took place. Figure 1 shows students achievement changes in terms of different assessment:

![Figure 1](image_url)

*Figure 1* Student achievement changes in different assessments.

Although there could be various factors that affect the changes in student achievement, students’ consistent improvement of mathematical learning during the period of implementing project
based instruction provides general positive information regarding the influence of my research actions on student learning.

To triangulate the above results, I compared students’ individual average math grades before and after project based instruction was introduced. Figure 2 shows the individual achievement changes.

*Figure 2* Individual students’ average math achievement changes

Based on this data, eight students showed a gain in their math scores, three students showed a loss in their math scores, and two students had the same pre- and post-math grades. These findings seemed to support that student learning had been generally increasing since project-based instruction was employed. Because no causal relationships between project-based learning
and student achievement could be concluded, further research is needed to explore how project-based learning can influence student learning.

Conclusions

This research experience provided me with daily opportunities to gain insight into the thoughts and feelings of my students. I had never really taken the time to ask them questions about the curriculum or methods of presentation. This study allowed me to restructure my method of instruction to include lessons and activities to keep students actively engaged and motivated while allowing for both individual work and collaboration with their peers. There was a change from a teacher-centered classroom, where the teacher teaches the process, the students practice it and independently complete the assignment, to a classroom where the teacher is mainly the facilitator and the students work on the day’s lesson with their cooperative learning group. It was an eye-opening experience for me to watch the growth my students showed while working cooperatively toward their goals. What began as constant arguing ended with a classroom of students where the majority of the groups could discuss problems and arrive at solutions that left them feeling successful. Through the trials and tribulations I feel they have gained knowledge that goes far beyond the data on the charts, they learned ways to work respectfully together with their peers toward a common goal. This finding agrees with that of Ryan and Patrick (2001) who found that when students believe they are encouraged to know, interact with, and help classmates during lessons they tend to engage in more adaptive patterns of learning than the previous year. In Mueller and Flemming’s (2001) research, they also described difficulties of some collaborative groups at the onset. They reported that despite obvious problems that some groups encountered in working together, all the groups found ways to
cooperate respectfully to the point where they could successfully complete the requirements of the project.

The project based instruction provided students with a task they saw as enjoyable from the beginning. Middleton and Spanias (1999) found in their research that when students find a task enjoyable, it will be intrinsically motivating and students will learn for the sake of learning. Lepper (1998) also stated that if students were intrinsically motivated to perform an academic task, they would spend more time engaged in the activity, learn better, and enjoy the task more than if they were extrinsically motivated. My research findings were consistent with previous findings. Initially, with regard to the journal question posed to my students, “Are you good at math? How do you know?”, three students in my study felt that they were good at math because they got good grades, while the other 10 felt they were bad at math because it was hard and they didn’t feel they got good grades. The grades were the extrinsic motivation, but it was clear that the students judged their ability based on that motivation. Throughout this project based instruction, my students seemed to grow more positive in their attitude and in their intrinsic motivation. Students increased their interests and motivation through project based learning. Project based instruction helped students to improve their internal motivation for learning mathematics.

This study has the potential to inform teachers regarding instructional decisions about cross-curricular lesson planning and the use of cooperative learning in the middle school classroom. Looking for real-world connections to mathematical concepts and providing opportunities for cooperative learning experiences within the classroom could greatly benefit other teachers and provide them with ideas to motivate students and increase participation without sacrificing student achievement. Ryan and Patrick (2001) stressed the importance of
students developing active and flexible approaches to problem solving. Project based instruction would be one way to bring active and flexible approaches to students in the classroom. My findings agreed with the researchers who felt that small group work, which exposes students to alternative solution methods and encourages students to reflect on their own strategies, should be used. They also suggested that more research needed to be done in this field to determine the impact of social issues on student motivation, engagement, and learning.

At the beginning of this research process, I was unsure about spending this much time on a new teaching strategy and worried that students wouldn’t do as well on district assessments. I found that it was well worth the time and the students performed well on the assessments. Project based instruction and collaborative learning groups are unusual characteristics in most middle school math classrooms. Many educators would agree that finding methods to create excitement and intrinsic motivation among students will enhance students’ conceptual understanding of content (Kloosterman & Cougan, 1994; Kollar et al., 2001). Slavin’s (1991) research agreed with those above studies. He found that students completing small group learning group tasks tended to have higher academic test scores, higher self-esteem, and greater comprehension of the content and skills they were studying.

In general, my results showed a positive relationship between project-based learning and students’ achievement. However, further study is needed to explore if that type of learning combined with student collaboration changed student achievement.

**Implications**

This summer our school district will be revising our math curriculum to align with the new Nebraska State Standards. I have thought a lot about which instructional practices related to
this research project that I will choose to implement and how those methods will fit the new curriculum.

I intend to begin the school year with lessons in collaborative learning. I feel that if students would have had the entire year to work on this specific instructional approach, they would have been more comfortable. The time frame of this project seemed too long to keep one group together, so I will try rotating groups each quarter. This will still give students nine weeks together to establish cohesiveness. It also will give students a chance to work with someone else if there happens to be a personality conflict or disruptive students within the group. Specific behaviors will be practiced and charts will be posted in the classroom reminding students of these expected positive behaviors.

I saw positive changes in my students when I assumed a facilitator role and intend to keep structuring lessons with that in mind. I also will keep the project based mathematics roller coaster project, adding more science skills and depending on the new math curriculum, perhaps adding more math skills there also. The student journals were probably the best piece of insight into the students’ thoughts for me, and I intend to keep using that next year. The students seemed to enjoy being able to express their thoughts honestly and it was a valuable tool that helped me gather data on the successes and failures of my teaching practices.

When I first started this research project, I worried that the collecting of data and journaling was taking too much of my time and attention and that I was cheating my students out of ‘teacher time’ with me. At the conclusion of this, I see that absolutely no one got cheated. Both the students and I gained a wealth of knowledge, both academically and about ourselves. We have all won.
References


Appendix A

Project Timeline

**Cooperative Learning Instruction**

<table>
<thead>
<tr>
<th>Date</th>
<th>Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3</td>
<td>Give students attitude inventory</td>
</tr>
<tr>
<td></td>
<td><strong>INTERVIEW 5 Students</strong></td>
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<tr>
<td>2-4</td>
<td>Introduce Cooperative Learning</td>
</tr>
<tr>
<td>2-5</td>
<td><strong>Broken Circle Activity</strong></td>
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<td>2-6</td>
<td><strong>Master Designer Shaper Activity</strong></td>
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<td>--Student Questionnaire</td>
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<td>2-10</td>
<td><strong>Jigsaw Puzzles</strong></td>
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<td>--Student Questionnaire</td>
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<td>--Group Evaluation</td>
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<tr>
<td>2-11 - 2-12</td>
<td><strong>Epstein’s Four-Stage Rocket Activity</strong></td>
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<td></td>
<td>++Discuss Constructive and Destructive Group Behaviors</td>
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<tr>
<td></td>
<td>--Student Questionnaire</td>
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<td></td>
<td>--Group Evaluation</td>
</tr>
<tr>
<td>2-15 – 2-16</td>
<td><strong>Spaceship Task Activity</strong></td>
</tr>
<tr>
<td></td>
<td>++Conflict Resolution Strategies</td>
</tr>
<tr>
<td></td>
<td>++Positive Requests</td>
</tr>
<tr>
<td></td>
<td>--Student Questionnaire</td>
</tr>
<tr>
<td></td>
<td>--Group Evaluation</td>
</tr>
</tbody>
</table>

**Project Based Instruction**

2-18  | Pretest                                                                |
Began 2-19 | Lesson on Newton’s Laws of Motion (Science book pgs. B78-B85, B94-B109) |
          | Discussion and activities demonstrating the 3 Laws of Motion           |

**Balloon Rockets**
**Match Missiles**

These activities involve students collecting data, measuring and using the formulas for speed and exploring Newton’s Laws

++Assess with Cooperative Learning Rubric

Began 3-2  | Lesson on Velocity, Acceleration and Gravity (Science book pgs B86-B93) |
**How Fast and How Far Does It Fall?**
**Will Paper Fall Like Stone**
**Falling Fun**

++Assess with Cooperative Learning Rubric

3-16 – 3-17  Questionnaire on Roller Coasters (Student Worksheet 1)
--Large group discussion – compare designs and information discovered
--Journal
==Students will complete questionnaire individually. Then large group
discussion will emphasize what makes roller coasters thrilling (height,
speed, duration, angle of drop, type of coaster, restraining devices,
environment, etc)
=In cooperative groups, students will compare the roller coaster designs
they sketched on the back of their worksheet. Things the group should
focus on are: safety, feasibility, angles, length, ride duration, and speed.
++Assess with Cooperative Learning Rubric

3-18 – 3-19  Internet Scavenger Hunt (Student Worksheet 1 A)
Students complete these individually, then in cooperative groups,
then the information is discussed as a class. Discussion will focus on
interesting information that was discovered during the research.
==This activity prepares the students with a knowledge base of roller-
coasters. The information they discover will help them with the rest
of the unit.
++Assess with Cooperative Learning Rubric

3-19 – 3-23  Internet Rollercoaster Search (Student Worksheet 2 and 2 A)
Students work independently, then with their cooperative group,
then the information is discussed as a class. (Review with students mean
and range of sets of data)
++Assess with Cooperative Learning Rubric

3-24  Finding Average Speed Worksheet (Student Worksheet 3)
Students work in cooperative groups to determine the mean speed
of given roller coasters.
==Discussion will follow on findings and conclusions from this activity.
The students will be asked to compare speeds found from the Internet
search to the speed they calculated. Discuss how using the top speed on
the Internet information makes the ride look more exciting than using the
average speed of the entire ride.
==Discussion will include safety factors that need to be considered when
designing a rollercoaster in relation to the height of drop and speed.
(Number of people in the cars and the ability to stop if needed, laws of
motion, the type of track after a steep hill- can’t be too curved if track is
too fast, etc.)

**INTERVIEW SELECTED STUDENTS**

3-26 – 3-27  Scale Drawing of Roller coasters (Student Worksheet 4)
In cooperative groups, students will complete the scale drawing activity. This activity is to help students understand the actual length of a roller coaster taken from a picture using a scale and identifying how the angle affects the length of the downhill track.

Upon completion of the activity, the students will discuss as a whole group the findings and conclusions from the activity.

**3-30 – 4-12 Performance Assessment**

Students will be asked to help a fictional amusement park increase its sales by designing a new roller coaster. They will use their knowledge of maximum hill height, speed, angle of descent, safety, and ride duration to complete a planning sheet. Students will draw a sketch of their proposed roller coaster. They will work with their cooperative group to evaluate each other’s work and give feedback on the feasibility of their planned roller coaster. Once feedback is received, students will create a scale drawing of their roller coaster on graph paper. The assessment will conclude with students writing a business letter to a roller coaster club requesting feedback on their design. (See rubrics for assessment guidelines)

++Assess with Cooperative Learning Rubric

**4-13 Students will experiment with their own roller coaster design**

by studying the interactive website:

www.Funderstanding.com/k12/coaster

**4-14 – 4-17 Three Dimensional Model: Students will work in their**

Cooperative groups to decide on which design will be used to create a three dimensional model. All groups will use the same materials to create a marble roller coaster. Materials available for use to the groups:

- Foam board base
- Index cards
- Masking tape
- 9X11 copy paper
- Plastic straws
- Tooth picks
- Construction paper

++Assess with Cooperative Learning Rubric

**4-21 Groups will present their individual designs and their group model to grades K-5.**

**4-22 Attitude Inventory**

**INTERVIEW SELECTED STUDENTS**
Appendix B

Attitude Survey

Mathematics Attitude Inventory

Check one:  
A = Always  
S = Sometimes  
N = Never

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>S</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I look forward to math class.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I would rather work on any other subject than math.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I get good grades in math.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I think math is something I don’t need to understand.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I admire other students who are good at math.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I like when math problems really make me think.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I don’t think I am good at math.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I think some kids just know how to do math and some kids just don’t understand it – and studying more won’t help.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Working in groups helps me understand math better.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. I’m not sure of my math answers, even on simple problems.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. It is important for me to do well in math.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. I feel comfortable asking questions in math class if I don’t understand something.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. I am comfortable sharing my mathematical ideas with the whole class.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Working in small groups just makes me more confused about math.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. I am more comfortable sharing my ideas in a small group than with the whole class.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. I understand math better when we do activities rather than just the teacher explaining it from the textbook.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

Pre-Project Interview Questions

1. What do you like about working in groups during Math class?

2. What makes working in a math group difficult or not fun?

3. How do you prefer your teacher would pick the groups? (student’s choice, random, teacher choice)
   Why do you prefer this method?

4. When you do group work, what do you do when you and your partner have different answers?
   How do you decide who is correct?

5. How do you know if your partners are listening to you when you are working in a small group?

6. What (if anything) makes learning and doing math fun?

7. What makes math not so fun or frustrating for you?

8. What can your teacher do during class to help you understand math better?

9. How successful do you think you will be on the roller coaster project that we will be doing in math? Why?
Appendix D

Post Project Interview Questions

1. What do you like about working in small groups during math class?

2. What makes working in small groups difficult or not fun?

3. Compared to the beginning of this project, how has your motivation changed with regard to math and participating in small group work?

4. How successful do you think you were on the roller coaster project? Did this change from the way you felt at the beginning of the project? How and why?

5. How difficult was the roller coaster project for you? What was the most difficult part of the project? What would have made the project easier for you?

6. Some students think they understand math better when it is explained by a student rather than by a teacher. How do you feel about that?

7. How important was it for you to do well on the roller coaster project? Why do you think your feelings about the project’s importance to you increased, decreased, never changed?

8. Did your group work together on the project or were there one or two people who seemed to make all the decisions for the group?

9. Do you think I should use this project for next year’s class? Why or why not?
Appendix E

Math Assessment

Measures of Central Tendency

Name _______________________________  Date ____________________

1. This table shows the heights, in inches, of the seven Ramos cousins.

<table>
<thead>
<tr>
<th>Name</th>
<th>Height</th>
<th>Name</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloria</td>
<td>55</td>
<td>Rueben</td>
<td>45</td>
</tr>
<tr>
<td>Jamie</td>
<td>49</td>
<td>Rodolfo</td>
<td>56</td>
</tr>
<tr>
<td>Leticia</td>
<td>59</td>
<td>Veronica</td>
<td>52</td>
</tr>
<tr>
<td>Manuel</td>
<td>65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Ramos cousins stood in a line from tallest to shortest. Who was standing in the middle?

2. Find the median of 26, 52, 18, 39, and 26.

3. Find the mode of the set of data. 10, 17, 16, 13, 17, 16, 10, 13, 16, 15

4. Find the mode of the data. 19, 17, 18, 15, 17, 18, 19, 16, 18, 12

5. Find the mode of the data. 16, 14, 13, 11, 14, 13, 16, 11, 13, 10

6. What is the median of 36, 15, 60, 69, and 15?

7. Find the median of 36, 15, 60, 69, and 15.

8. Find the mean of the set of numbers, to the nearest hundredth. 30, 10, 40, 21, 17, 32, 18, 11
9. The average number of days of thunderstorms at 16 Canadian airports are given. Find
   the range.
   7 12 21 7 27 23 25 23
   17 13 2 21 2 24 2 25

10. Find the range of the data.   1, 17, 11, 32, 15, 20

11. Find the range of the data.   3, 16, 24, 29, 22, 19

12. What is the mean of the following data: 7, 12, 6, 10, 4, 9, 8?

13. Find the range of the set of numbers. 16, 9, 15, 22, 37, 13

14. Find the mean of the set of numbers, to the nearest hundredth.
   15, 26, 30, 38, 13, 27, 13, 18

15. The average number of days of thunderstorms at 16 Canadian airports are given. Find
   the range.
   6 13 21 6 22 23 28 28
   17 13 1 20 6 24 2 28

16. Find the mode of the set of data. 12, 19, 18, 14, 19, 18, 12, 14, 18, 11
17. The high temperature for July 15 during the past 10 years is given in the table below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>83 F</td>
</tr>
<tr>
<td>1989</td>
<td>85 F</td>
</tr>
<tr>
<td>1990</td>
<td>94 F</td>
</tr>
<tr>
<td>1991</td>
<td>93 F</td>
</tr>
<tr>
<td>1992</td>
<td>92 F</td>
</tr>
<tr>
<td>1993</td>
<td>83 F</td>
</tr>
<tr>
<td>1994</td>
<td>78 F</td>
</tr>
<tr>
<td>1995</td>
<td>91 F</td>
</tr>
<tr>
<td>1996</td>
<td>83 F</td>
</tr>
<tr>
<td>1997</td>
<td>79 F</td>
</tr>
</tbody>
</table>

What is the mode of these temperatures?

18. What is the median of 3, 110, 61, 27, and 24?

19. What is the mean of the following data? 9, 3, 7, 13

20. What is the mean of the following data? 13, 7, 5, 11
Appendix F

Mathematics Assessment

Geometry Concepts

Choose the correct answer for each. Use this figure for questions 1–12.

1. \( BF \) bisects \( DG \). Ron measured \( FG \) and found it was 10 cm. What is the length of \( DG \)?
   - A. 5 cm
   - B. 10 cm
   - C. 20 cm
   - D. not given

2. \( EB \) bisects \( \angle AEF \). What is the measure of \( \angle EBF \)?
   - A. 27.5°
   - B. 55°
   - C. 110°
   - D. 125°

3. What is the measure of \( \angle EBF \)?
   - A. 35°
   - B. 45°
   - C. 55°
   - D. 125°

4. Which pair of lines are parallel?
   - A. \( AB \) and \( CG \)
   - B. \( AC \) and \( DG \)
   - C. \( EB \) and \( CG \)
   - D. \( BF \) and \( DG \)

5. Which lines are perpendicular?
   - A. \( BF \) and \( DG \)
   - B. \( BF \) and \( CG \)
   - C. \( AD \) and \( DG \)
   - D. \( AD \) and \( EB \)

6. Which lines are neither parallel nor perpendicular?
   - A. \( AC \) and \( FG \)
   - B. \( BF \) and \( DG \)
   - C. \( CG \) and \( BF \)
   - D. not given

7. What kind of angle is \( \angle BAD \)?
   - A. right
   - B. acute
   - C. obtuse
   - D. straight

8. What kind of triangle is \( \triangle BFE \)?
   - A. isosceles
   - B. equilateral
   - C. right triangle
   - D. right isosceles

9. \( DF = FG \). If you drew \( DB \) and \( BG \), what kind of triangle would \( \triangle DBG \) be?
   - A. right
   - B. equilateral
   - C. isosceles
   - D. scalene

10. What kind of quadrilateral is \( \square BCGD \)?
    - A. rhombus
    - B. rectangle
    - C. parallelogram
    - D. trapezoid

11. How many right triangles appear to be in this figure?
    - A. 1
    - B. 2
    - C. 3
    - D. 4

12. What kind of quadrilateral is \( \square BCGF \)?
    - A. square
    - B. rhombus
    - C. rectangle
    - D. not given
Choose the correct answer for each. Use these figures for questions 13–16.

13. Name two congruent triangles.
   A. \( \triangle ABC \) and \( \triangle XYZ \)
   B. \( \triangle ABC \) and \( \triangle DEF \)
   C. \( \triangle DEF \) and \( \triangle XYZ \)
   D. \( \triangle XYZ \) and \( \triangle PQR \)

14. Which two triangles are similar but not congruent?
   A. \( \triangle ABC \) and \( \triangle DEF \)
   B. \( \triangle ABC \) and \( \triangle PQR \)
   C. \( \triangle XYZ \) and \( \triangle PQR \)
   D. \( \triangle DEF \) and \( \triangle PQR \)

15. What is the measure of \( \overline{ZY} \)?
   A. 2.5 cm  
   B. 5 cm  
   C. 10 cm  
   D. 20 cm
Appendix G

Science Assessment

Newton’s Laws of Motion

Name ___________________________ Date ___________________________

Reviewing Concepts: Multiple Choice

Circle the letter of the answer that best completes the statement.

1. An example of static charges is
   a. clothing sticking to each other after being in the dryer.
   b. getting shocked when touching a lamp after walking across a carpet.
   c. hair sticking to a balloon that has been rubbed on clothing.
   d. all of the above.

2. The moon is kept in orbit around the Earth by the force of
   a. magnets.
   b. static charges.
   c. the Earth’s gravity.
   d. the wind.

3. The amount of matter in a bowling ball differs on each planet.
   a. changes in outer space due to weightlessness.
   b. changes under water.
   c. none of the above.

4. The combination of two or more forces acting on the same object is
   a. gravity.
   b. net force.
   c. mass.
   d. relative motion.

5. All of the following are types of motion EXCEPT
   a. circular.
   b. vibrational.
   c. straight-line.
   d. relative.

6. Compared to distance, displacement is
   a. always longer or equal to distance.
   b. sometimes longer and sometimes shorter than distance.
   c. always shorter than distance.
   d. always equal to distance.

7. According to the law of inertia, an object at rest
   a. is a very rare event.
   b. stays at rest until a force acts on it.
   c. needs a tremendous amount of force to move it.
   d. can never move.

8. A bobsled is kept in a circular path by a force that is
   a. a push.
   b. a pull.
   c. gravity.
   d. displacement.

9. Newton’s second law describes the relationship between mass, acceleration, and
   a. force.
   b. inertia.
   c. gravity.
   d. weight.

10. A force that can act in the opposite direction of the downward pull of gravity is
     a. inertia.
     b. weight.
     c. acceleration.
     d. air resistance.

11. In space, if an astronaut pushed her jetpack away from her, the jetpack would
     a. push back.
     b. create a static charge.
     c. be attracted to the astronaut due to magnetism.
     d. fall to Earth immediately due to the Earth’s gravity.

12. According to Newton’s second law, the greatest force using a hammer would be from a
     a. heavy hammer swung slowly.
     b. light hammer swung slowly.
     c. heavy hammer swung quickly.
     d. light hammer swung quickly.
### Reviewing Main Ideas: Sentence Completion

Complete each sentence with the correct word or phrase.

<table>
<thead>
<tr>
<th>force</th>
<th>displacement</th>
<th>friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>distance</td>
<td>acceleration</td>
<td>gravity</td>
</tr>
</tbody>
</table>

13. A push or pull is a **force**.

14. The force of attraction between any two objects is **gravity**.

15. **Distance** is the total length of the path between two points.

16. **Acceleration** includes direction and path length.

17. The change in velocity during a particular time period is **acceleration**.

18. **Friction** is a force between surfaces that resists the movement of one surface past another.
Appendix H

Students’ Journal Prompts

Week 1:
How successful do you feel at 6\textsuperscript{th} grade math? Have you ever felt differently about math than you do now? If so, when and why? How do you know when you are or are not successful?

Week 2:
What do you wish math class would be like? Do you like to work in groups during class or would you rather have the teacher give the instruction and then assign the work?

Week 3:
Are you more interested in the Roller Coaster project than our regular math class? Explain why or why not. Is this project helping you with math skills? If so, please explain what skills you have used in the project so far.

Week 4:
How successful do you feel thus far about your Roller Coaster project? Please explain. Are you more motivated with this type of instruction rather than our regular math class? If so, why or why not?

Week 5:
We worked in cooperative groups during this project. Do you like this type of group work, or would you rather work on your own? Please explain.

Week 6:
If you could design a math class that would keep kids motivated and excited about math and still cover the district’s curriculum, what would your class look like? What would the teacher and kids be doing each day?
Appendix I

Cooperative Learning Student Questionnaire

1. How interesting did you find your work in the group?
   _____ very interesting
   _____ fairly interesting
   _____ somewhat interesting
   _____ not very interesting
   _____ I was not interested at all

2. How difficult did you find your work with the group?
   _____ extremely difficult
   _____ fairly difficult
   _____ sometimes difficult
   _____ not too difficult, just about right
   _____ very easy

3. Did you understand exactly what the group was supposed to do?
   _____ I knew what to do.
   _____ At first I didn’t understand.
   _____ It was never clear to me.

4. How many times did you have the chance to talk during the group session today?
   _____ none
   _____ one or two times
   _____ three or four times
   _____ five or more times

5. If you talked less that you wanted to, what were the main reasons?
   _____ I felt afraid to give my opinion.
   _____ Somebody else interrupted me.
   _____ I was not given the chance to give my opinion.
   _____ Nobody paid attention to what I said.
   _____ I was not interested in the problem.
   _____ I was not feeling well today.

6. Did you get along with everybody in your group?
   _____ only a few of them
   _____ most of them
   _____ all of them, except one
   _____ all of them

1. Who did most of the talking today?

2. Who did the least talking in your group?

3. Who had the best ideas in your group today?

4. Would you like to work with the group again? If not, why?