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Gwendolyn M. Harris

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# Montessori Middle Schoolers Mastering Mathematical Concepts through Real-World Connections

An Action Research Report  
By Gwendolyn M. Harris

Montessori Middle Schoolers Mastering Mathematical Concepts through  
Real-World Connections

By Gwendolyn M. Harris

Submitted on December 18, 2013  
in fulfillment of final requirements for the MAED degree  
St. Catherine University  
St. Paul, Minnesota

Advisor: \_\_\_\_\_

Date: \_\_\_\_\_

## Abstract

The purpose of this action research was to determine the effects of incorporating mathematical projects involving real-world situations into the mathematics curriculum on student's mastery of mathematical concepts in a Montessori middle school program. The research study was conducted in a private Montessori middle school program with seven, seventh grade students. Data collection methods included archived pre-test and post-test scores from the past two years' seventh grade students, pre-test and post-test scores from this years' seventh grade students, field notes, narratives, and student surveys. The student's displayed excitement in the incorporation of mathematical projects within their mathematics curriculum and the data showed a positive impact on students' mastery of mathematical concept understanding when the incorporation of mathematical projects were included into their mathematics curriculum.

Students cannot wait to visit the classroom they will be a part of next year.

Approximately mid-January of each school year, the Montessori school I teach at has students who will be moving to a new level the following year participate in a level visit. Kindergarten aged students visit the lower elementary classroom, third grade students visit the upper elementary classroom, and the sixth grade students visit the middle school classroom. These level visits are for one day and help start the transition process that students will go through the following school year. During the sixth grade visit to middle school, students are given general reading, writing, and mathematical assessments. The results of the mathematical assessment has perplexed me year after year. A ten question test is administered, without the use of a calculator. The test includes addition, subtraction, multiplication, and division problems with decimals and fractions. Although the students have typically attended Montessori school since preschool, an environment rich with didactic materials that foster learning mathematical concepts, they score very low. Many students leave over half of the test blank and of the questions that are answered, many equations are set up incorrectly. At the end of the school year, the sixth grade teachers say that the majority of students have completed the entire upper elementary curriculum. The emphasis seems to be on quantity of mathematics completed rather than the quality of mathematical concepts learned. As the students enter the middle school program, in seventh grade, this idea of just getting through the mathematics curriculum continues to outweigh mastering concepts. Students and their parents ask how long it will take to finish the mathematics book. They are focused on what mathematics class they will be able to take as a freshman in high school. My action research project to have Montessori middle school students master mathematical concepts

by incorporating real-world problem solving into the curriculum came out of this focus on the amount of mathematics completed as opposed to mastering concepts.

For the past six years, I have taught seventh grade mathematics to groups of students in a Montessori middle school setting. The mathematics curriculum followed is based on the University of Chicago School Mathematics Project. In middle school, our end goal is for students to understand mathematics concepts and be able to apply them in real-world problem-solving situations. When students begin their middle school experience, they are often unclear and confused about the mathematics curriculum, their mathematical abilities, and their mathematics program placement. The seventh grade students begin their mathematics study in the *Transitions Math* text book. To alleviate fear of the unknown, as this is the students' first experience using a mathematics text book, students are asked, at the start of the school year, to work together through the first chapter. This is to be sure students understand the way the book is designed for completion as well as to encourage discussion about mathematics with their peers. After the first chapter is completed, students are able to move through the following chapters at a pace that is comfortable, for them individually, in order to reach mastery of concepts. Chapters typically consist of nine or ten lessons. The students take a pre-test, two quizzes that are interspersed throughout the chapter, a progress self-test and a post-test. The expectation is that students reach 90% mastery on post-test before moving to the following chapter. As mathematics skills build upon each other, tests are retaken until mastery is attained. The textbook is designed to be either a one or a two year program, depending on the student's ability to reach mastery. Typically, students in my class have mastered ten chapters of thirteen in the seventh grade year. I have had students work at a slower pace,

mastering five chapters, as well as students who have mastered the entire text book and moved on to the next text book in the series; *Algebra*. The time it takes to complete a text book is dependent on student's mastering concepts, not just doing the work.

At the school in which I work, it has been a growing concern that students' confusion concerning mathematical pacing is enhanced when parents put unrealistic expectations upon their child, i.e. getting as far as possible, as fast as possible, not focusing on mastering concepts. Parents push for their children to complete the entire *Transitions* text book quickly in order to get through the *Algebra* text book and possibly even the *Geometry* text book, before beginning high school. Tom Loveless (2008) pointed out that this theory was planted in the minds of these parents when, in 1990, President Clinton announced that only one quarter of children in the United States take algebra before high school, while middle school students around the world are not just taking algebra, but also taking geometry (p. 2). Upon hearing President Clinton speak about the entire nation's educational poor standing, many parents started to perceive it typical for their eighth grade student to complete an algebra program before entering high school. As the expectations of parents increased so did the enrollment of middle school students in algebra programs. By 2007, thirty-one percent of all eighth grade students in the United States were enrolled in algebra programs, nearly doubling the percentage in 1990 (Loveless, p.2). Students are being placed in higher mathematics programs and moving through them at a faster pace, whether they are academically ready or not. Irene Warren (2008), posted, "Algebra in eighth grade was once reserved for the mathematically gifted student" (2008, para. 2). Our society no longer sees algebra as a track for just the "gifted", but for everyone. This attitude of "do more, faster", regardless of mathematical

ability is not realistic and only causes frustration, not a more productive student.

Morrison (2012) quoted a student that had been pushed, with parent pressure, through the mathematics curriculum, “Honestly, being in advanced math made me hate the subject” (p. 31). If a student “hates” the subject, will they want to stick with it and continue to learn more of it? The answer to this is a simple “No”. When a student finds a subject or task unenjoyable, it is because they do not understand it. With this lack of understanding, the student is frustrated and just wants it to stop. They will not willingly stick with the subject or task and will fake their way through the process rather than truly understanding concepts. It takes great effort to overcome this fear of failure within students that cannot keep up with these expectations.

This national goal to move children ahead in advanced mathematics is not having the intended outcome of “smarter” students ready to compete in the world. While more middle school students are enrolled in algebra programs, average mathematical scores are not higher. Sean Cavanagh (2008) pointed out that “Many of the states with the highest percentage of students enrolled in 8<sup>th</sup> grade algebra have the lowest average math scores in that grade on the 2007 NAEP, ...while the opposite effect plays out in other states” (2008). This evidence shows the disconnect between exposure to curriculum and concept understanding.

Heidi Janzen (2005) stated that “Teachers need to be especially aware of their students' attitudes and how they can impact their problem-solving skills. These teachers should also be aware of their own attitudes and model a positive approach to problem solving” (2005, para. 12). It is important for the teachers to model a positive attitude, creating a comfortable and safe environment for students to be able to take risks, sharing



their ideas in groups, and focus on the process rather than the actual solution to the problem (Janzen, 2005, para. 14). The problem solving process is not a process that should be rushed. Students need time to fully explore and share and apply all ideas that enter their minds. This thinking connected to application is what I hope will improve students understanding of mathematical concepts.

The research project was conducted in my Montessori middle school classroom. At this particular Montessori school, students are not accepted into the middle school program unless they have attended the school at least one year in the nine through twelve upper elementary program. Of this year's group of seven students five are boys and two are girls. One student entered Montessori at the age of twelve, attending only one year of Montessori. This particular student had frequently been left home alone and chose to skip school on a regular basis. The student now lives with an aunt and uncle who provide more stability and make sure school is attended. Although no special academic deficiencies were identified for this student, the sixth grade year was repeated due to the amount of schooling that was skipped. Two students entered at the age of ten. Both came from traditional schools. Both families had just learned of the Montessori method and wanted their children to experience this method of education. Two entered at six years of age, having attended traditional pre-schools, and two entered at five years of age. One attended another Montessori program and the other did not attend any other school previously. None of the students require special academic attention. The students all came from two Montessori, upper elementary, classrooms and both previous teachers shared that each student had completed the entire Montessori, upper elementary, mathematics curriculum.

The question – What are the effects of incorporating mathematical projects involving real-world situations into the mathematics curriculum on student’s mastery of mathematical concepts in a Montessori middle school program? – guided my research study. After researching what helps to solidify concepts in student’s minds, I found connecting the mathematics to real-world problem-solving to be the key factor. The National Council of Teachers of Mathematics (2006), explained that the focus of mathematics is no longer on memorizing facts or methods for problem solving, but thinking about and understanding real world problems are what is important (2006, para. 1 and 2). It is this application of concepts that helps real understanding and learning to take place. In order to help students make the connections between their textbook and the world in which they live, I searched for a way to actively engage and excite the students. The mathematics series offers project ideas after each chapter presented in the mathematics text book. The projects are varied to meet the abilities and interests of many different students (Usiskin, Feldman, Davis, Mallo, Sanders, Witonsky, Flanders, Polonsky, Porter, & Viktora, 2002, p. T41). Student engagement in open-ended projects can offer a solution to help students focus on the quality of the mathematics they learn over the quantity of mathematics they cover. While these projects will require more time for students to complete, they will offer students opportunities to use real data that people in careers would use, practice a higher level of persistence while solving problems, choose and take ownership of a task, share their knowledge in a variety of creative ways, and evaluate their own academic achievement in a way other than testing (Usiskin, et al, 2002, p. T41). The students’ presentations of these projects will also provide parents another way to see the true mathematical application success in their children.

I developed an action research process that incorporated real-world projects involving mathematical concepts into the curriculum to investigate the effect they had on middle school students in a Montessori setting gaining mathematical concepts. I compared seventh grade students' ability to master concepts from the previous two school years, where mathematics projects were not a part of the curriculum, with this year's group of seventh grade students' ability to master concepts who had the incorporation of mathematics projects in the curriculum. The process of this investigation is outlined in the next section.

#### Description of Research Process

I chose to start my action research project by explaining the mathematics program to the parents of the students I would be working with this school year. At a "Back to School Meeting" held for parents only, before school started, on August 12, 2013, I explained the process and the expectation for students to read the lesson, create a notecard of important information, and complete the *Covering the Reading* questions independently. As a group, students would review the *Covering the Reading* questions as well as complete the *Applying the Mathematics* and *Review* questions. *Exploration* questions would be optional for the students. Seventh grade students would be working from the *University of Chicago School Mathematics Project Transitions Mathematics text*. I felt it vital for parents to know that concept understanding was the focus rather than quantity of mathematics covered. I emphasized that the pace of mathematics coverage depended on the student's ability to demonstrate concept mastery to a minimum of 90% on post-tests taken after chapter lessons had been completed. During student-parent-teacher conferences, held the following three days, individual questions were

addressed and parents gave permission for any data collected to be used as part of my project. A copy of the permission form is included in the Appendix A.

The four data sources included: (1) observational data in which I expanded field notes of observations taken during the in-class mathematics groups as well as when students worked independently on mathematics into written narratives in order to understand how each student changed their understanding of mathematics concepts on a daily basis as the incorporation of mathematics projects was implemented, (2) surveys that related to how the students interpreted their mathematics concept understanding before and after the incorporation of mathematics projects and that served as a comparison for data collected from observations, (3) teacher-made tests that were given as pre-tests to get a base of concepts understood, quizzes to see concept progress, and post-tests to see how long mastery of concepts to a minimum of 90% took, and (4) school records of students from the past two years for comparison of the length of time it took students to reach mastery of concepts to a minimum of 90% when there was no incorporation of mathematics projects in their math program versus those this year's students who had the incorporation of mathematics projects in their mathematics program.

Chapter one of the mathematics curriculum was completed with the seventh grade middle school students from August 19, 2013 through September 6, 2013. At the start of this period, each student took a survey to document their personal interpretation of mathematics concept understanding before starting chapter one. A copy of the survey is in the Appendix B. During this period, I recorded daily field notes documenting observations of student's behaviors and mathematics concept understanding during mathematics group which were turned into narratives. The student's interpretations from

the surveys were compared to the teacher's interpretations from the narratives. Students took a pre-test, two quizzes, and a post-test, retaking the post-test until 90% mastery was acquired. Scores from the previous two years groups of students were used to compare the number of re-test required for mastery with this year's group of students. Students took a second, identical survey to the first, after the chapter one post-test was mastered to see if their personal interpretations of mathematics concept understanding had changed. This period of the process served to create a baseline to compare data collected after the incorporation of mathematics projects during chapters two and three.

On September 9, 2013, I started the second chapter with the students by explaining that each student would be choosing a project from the end of the chapter that tied the concepts that would be learned to real-world problem solving. The students read over each of the choices and then committed to working on one of the projects, at home. At this point, some students chose to self-check their lessons and complete the rest of the lesson questions on their own, asking questions for clarification as needed, while other students wished to continue to work in a small group as they did for chapter one. The students took a pre-test for chapter two, as well as two quizzes, then shared their projects with the group after completing all of the chapter two lessons. Finally, a post-test was taken by each student until mastery to 90% was reached. The number of times it took to reach mastery of concepts to 90% was compared to the past two year's groups of students. The students took a third survey, identical to the first and second, again to check for student perception of mathematics concept understanding. I compared their beliefs to the field notes and narratives that I continued to record. This portion of the plan lasted until September 27, 2013.

During the period of September 30, 2013 through October 4, 2013, the middle school students participated in internship programs. Half of the students worked in other Montessori classrooms, helping younger students with their work. The students that participated in the classroom internships had the opportunity to revisit mathematics materials and concepts from the elementary and preschool levels. Students that participated in business internships used mathematics skills in real-world situations. Two students worked in businesses, an ice-cream shop and a book store, helping with inventorying and having to make change for customers. Another student worked in an architectural firm, where mathematics skills were applied to drafting using a computer based program. While participating in internships, students did not use the mathematics text books, but all of the students, whether in classroom or business internships, had to apply mathematics to the real world.

On October 7, 2013, the students started to work on chapter three in the mathematics textbook, again with the incorporation of a second mathematics project. The same procedures were followed as with chapter two, except students were allowed to work through the chapter at a pace that was comfortable to them individually. All of the students began to self-check their answers and were responsible for asking for clarification of questions. On October 21, 22, and 23, 2013, I was out of the classroom with the eighth grade group of students. The seventh grade students continued to work independently on chapter lessons and had access to a co-teacher to clarify any questions they had. Student projects were shared on October 24, 2013, followed by post-testing on October 25. Re-tests were taken until mastery of concepts to a minimum of 90% was reached.

At that point I had the base data from chapter one, where students did not have the incorporation of student mathematics projects and data from chapters two and three, where students did have the incorporation on student mathematics projects. I compared the data from all three sessions.

In the following section I analyzed all the data sources outlined above. The focus of the analysis is to determine the effectiveness, if any, of the incorporation of mathematics projects involving real-world situations into the mathematics curriculum on student's mastery of mathematical concepts in a Montessori middle school program.

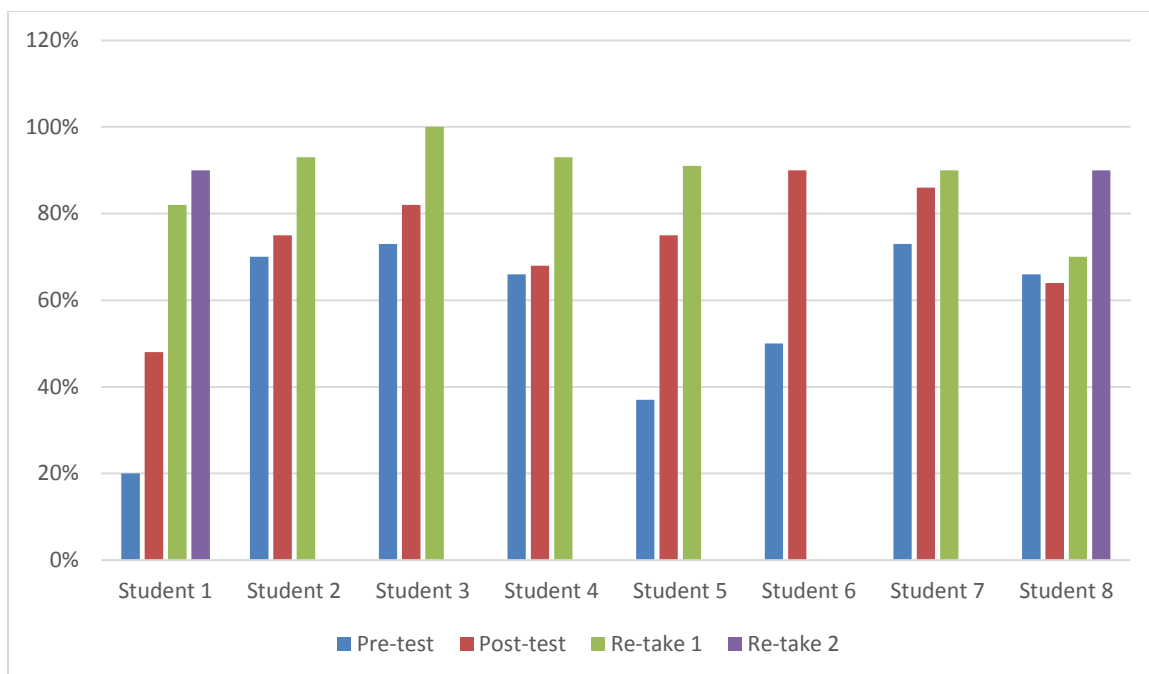
#### Analysis of Data

As summarized above, I analyzed data that was collected prior to, during, and at the conclusion of the incorporation of mathematical projects involving real-world situations into the mathematics curriculum in order to increase the credibility and validity of the results. The data collection techniques used included quantitative methods: archived pre-test and post-test scores, for chapters one, two, and three, as well as the number of times it took to reach 90%+ mastery of mathematical concepts for seventh grade students from the past two school years, who did not have the benefit of the incorporation of mathematical projects involving real-world situations included in their mathematics curriculum and student generated pre-test and post-test scores and the number of times it took to reach 90%+ mastery of mathematical concepts for seventh grade students from this school year. The 2013 student generated data was collected for chapter one, without the incorporation of mathematical projects involving real-world situations in their mathematics curriculum and then again after chapters two and three, where mathematical projects involving real-world situations were included in their mathematics curriculum.

Quantitative inquiry data was collected from this year's seventh grade students before and after the completion of chapters one, two, and three tests, in the form of student surveys, in order to understand student's interpretations of their mathematical concept understanding, with and without the incorporation of mathematical projects involving real-world situations in their mathematics curriculum. The qualitative methods of daily observations notes and narratives collected from this year's seventh grade students, before, during and after mathematical projects involving real-world situations were included in their mathematics curriculum, providing information to correlate daily behaviors with students' understanding of mathematics concepts.

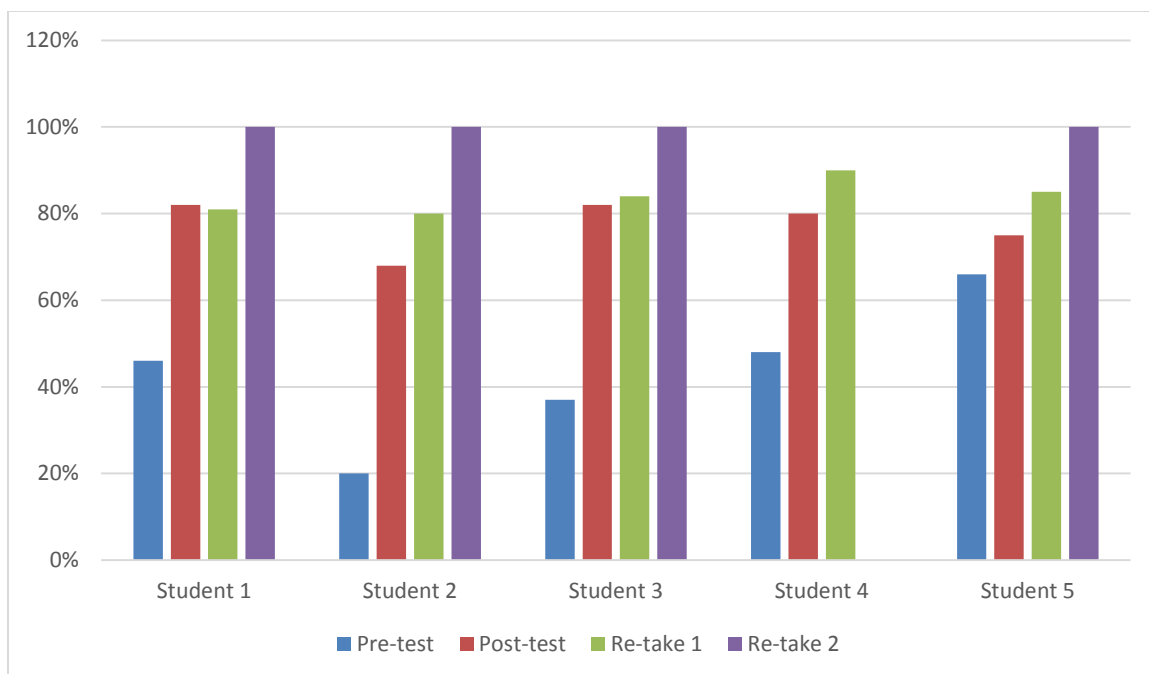
I started the data analysis by studying the chapter one pre-test scores, post-test scores, and re-take scores until 90% or higher was achieved of the students from 2011, 2012, and 2013. All of these scores were collected without the incorporation of mathematics projects in the mathematics curriculum. Figures 1, 2, and 3 display the students test scores respectively.





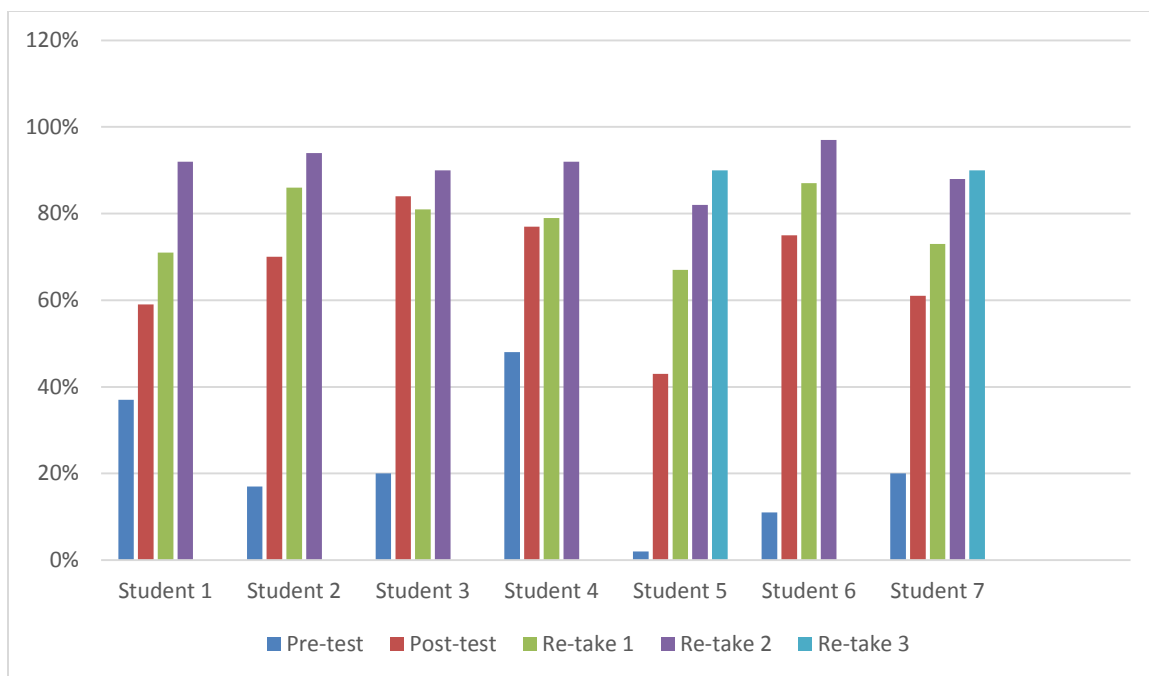
*Figure 1.* Scores for 2011 students, chapter one, without the incorporation of mathematics projects.

The average pre-test scores for the 2011 students, chapter one, with no incorporation of mathematics projects was 55%, with a median score of 66%, a mode of 73%, and a range of 53%. The average post-test score was 73%, with a median score of 75%, a mode of 75%, and a range of 42%. The average number of re-takes to reach 90% + mastery was 1, with a median of 1, and a mode of 1.



*Figure 2.* Scores for 2012 students, chapter one, without the incorporation of mathematics projects.

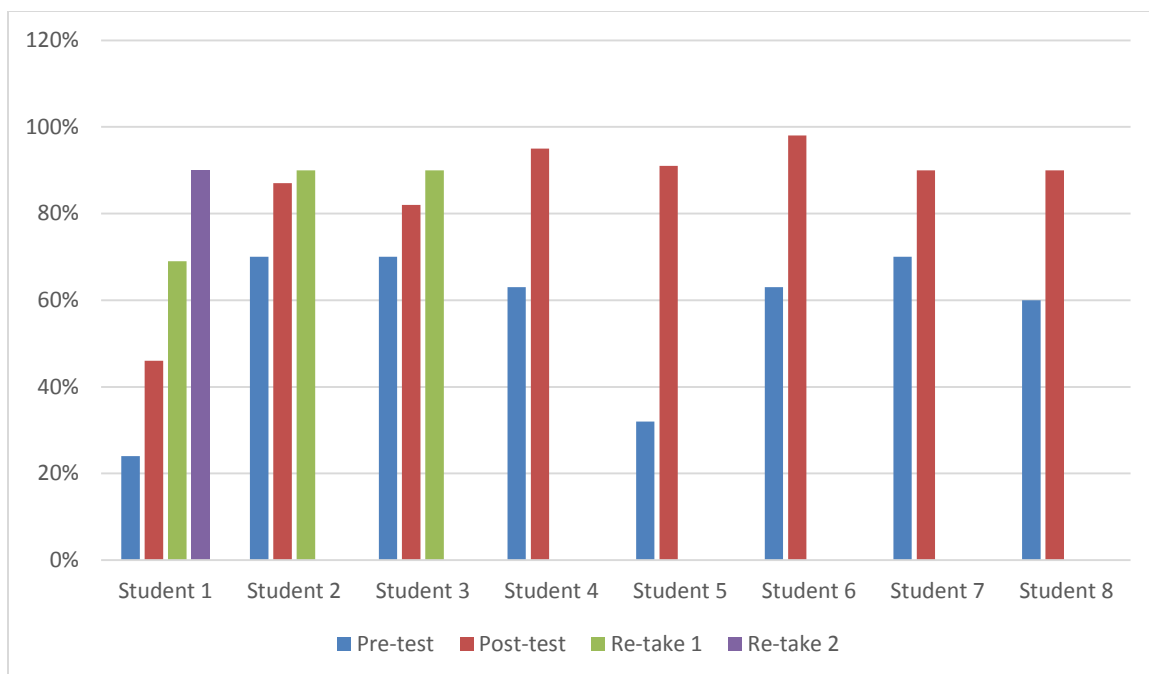
The average pre-test score for the 2012 students, chapter one, with no incorporation of mathematics projects was 43%, with a median score of 46%, no mode, and a range of 46%. The average post-test score was 77%, with a median score of 80%, a mode of 82%, and a range of 14%. The average number of re-takes to reach 90% + mastery was 1.8, with a median of 2, and a mode of 2.



*Figure 3.* Scores for 2013 students, chapter one, without the incorporation of mathematics projects.

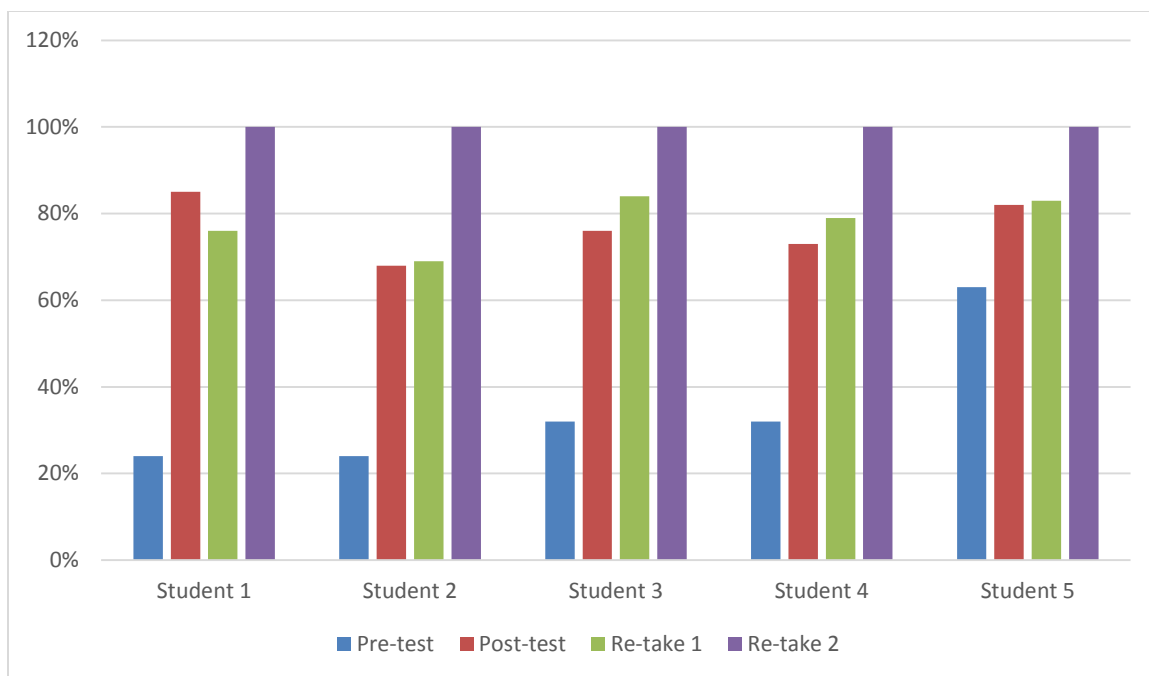
The average pre-test score for the 2013 students, chapter one, with no incorporation of mathematics projects was 22%, with a median score of 20%, a mode of 20%, and a range of 46%. The average post-test score was 67%, with a median score of 70%, no mode, and a range of 41%. The average number of re-takes to reach 90% + mastery was 2.3, with a median of 2, and a mode of 2.

After I analyzed the data by studying the chapter one pre-test scores, post-test scores, and re-take scores until 90% or higher was achieved of the students from 2011, 2012, and 2013, without the incorporation of mathematics projects in the mathematics curriculum, I then analyzed the data from chapter two, the same as I did for chapter one except the students from 2013 now had the incorporation of mathematical projects included in their mathematics curriculum. Figures 4, 5, and 6 display the students' scores respectively.



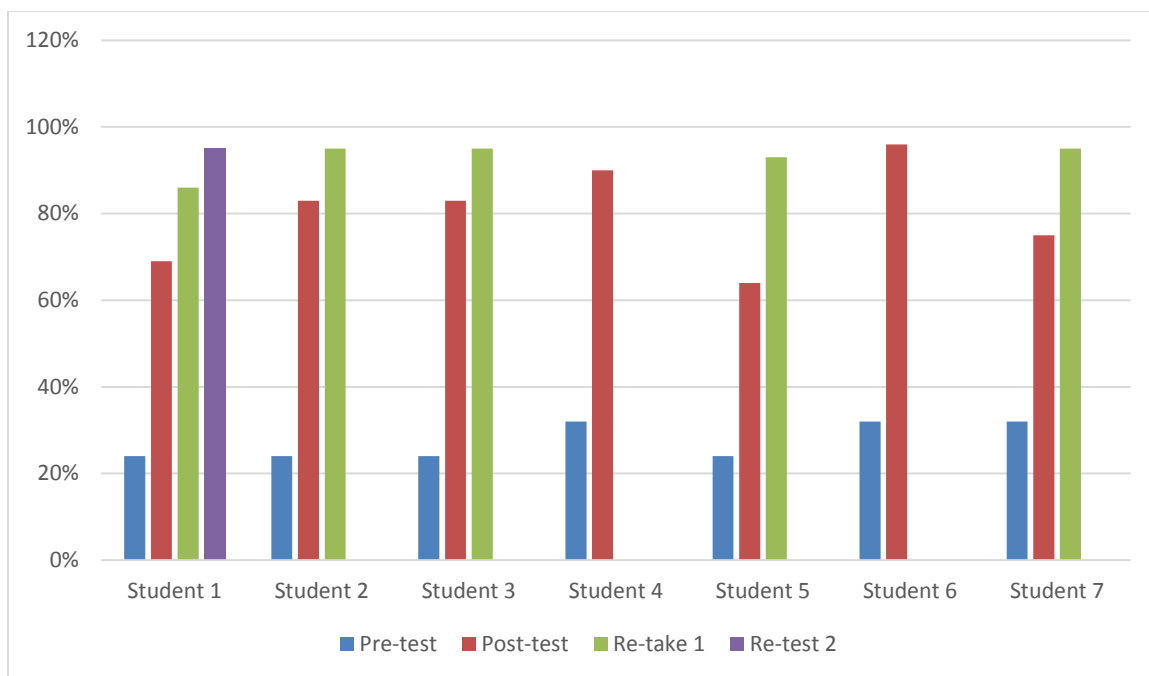
*Figure 4.* Scores for 2011 students, chapter two, without the incorporation of mathematics projects.

The average pre-test score for the 2011 students, chapter two, with no incorporation of mathematics projects was 57%, with a median score of 63%, a mode of 70%, and a range of 46%. The average post-test score was 85%, with a median score of 90%, a mode of 90%, and a range of 52%. The average number of re-takes to reach 90% + mastery was .5, with a median of 0, and a mode of 0.



*Figure 5.* Scores for 2012 students, chapter two, without the incorporation of mathematics projects.

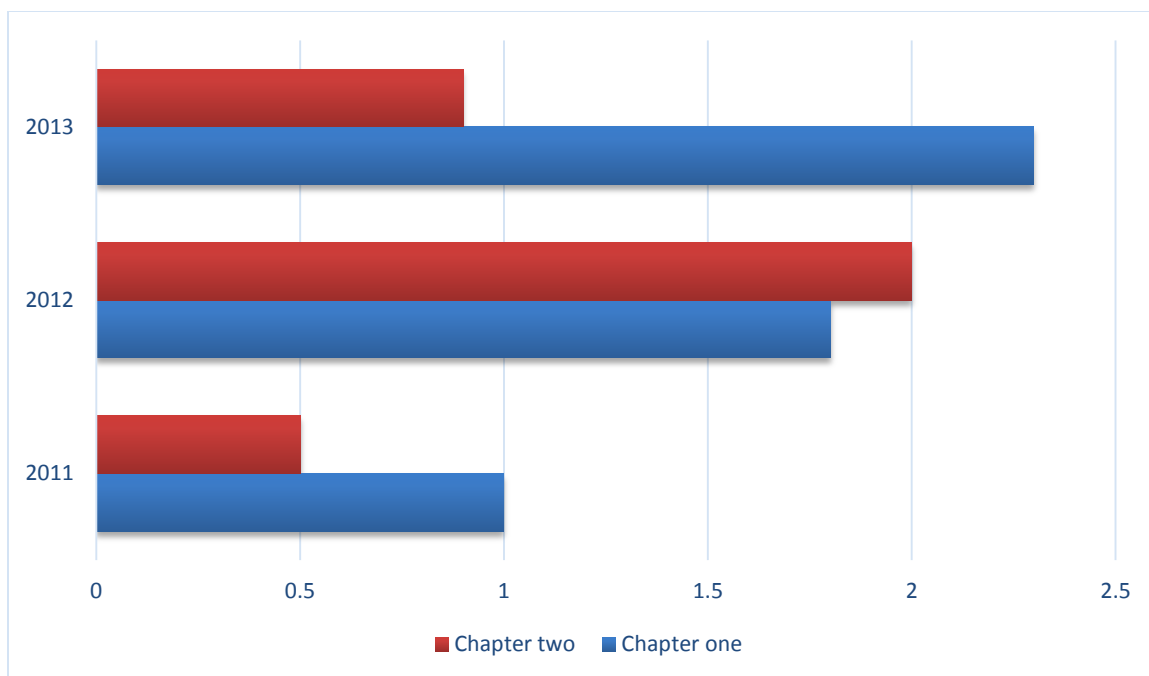
The average pre-test score for the 2012 students, chapter two, with no incorporation of mathematics projects was 35%, with a median score of 32%, a mode of 24%, and a range of 39%. The average post-test score was 77%, with a median score of 76%, no mode, and a range of 17%. The average number of re-takes to reach 90% + mastery was 2, with a median of 2, and a mode of 2.



*Figure 6.* Scores for 2013 students, chapter two, with the incorporation of mathematics projects.

The average pre-test score for the 2013 students, chapter two, with the incorporation of mathematics projects was 27%, with a median score of 24%, a mode of 24%, and a range of 8%. The average post-test score was 80%, with a median score of 83%, a mode of 83%, and a range of 32%. The average number of re-takes to reach 90% + mastery was .9, with a median of 1, and a mode of 1.

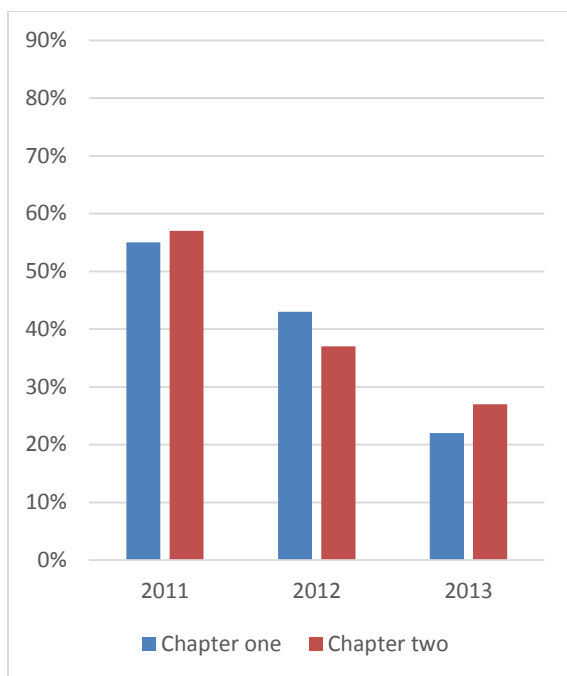
I then compared the average number of re-takes for students during 2011, 2012, and 2013, chapters one and two. Figure 7 displays this comparison.



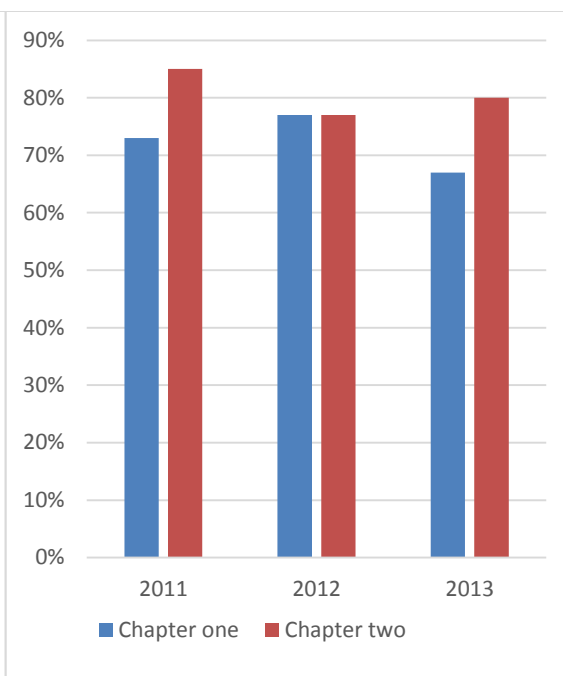
*Figure 7.* Comparison of the average number of re-takes for students during 2011, 2012, 2013, chapters one and two.

In comparing chapter one data with chapter two data, each year's average number of retakes decreased, however the 2013 group that had the benefit of the incorporation of mathematics projects for chapter two had the greatest average decrease in retakes, more than half, going from an average of 2.3 retakes down to an average of .9 retakes, an average difference of 1.4 retakes. The 2012 group had an average difference of .2 and the 2011 group had an average difference of .5.

Figures 8 and 9 display the comparisons of pre-test scores and post-test scores for all three groups after chapter one and chapter two.



*Figure 8.* Comparison of pre-test scores.



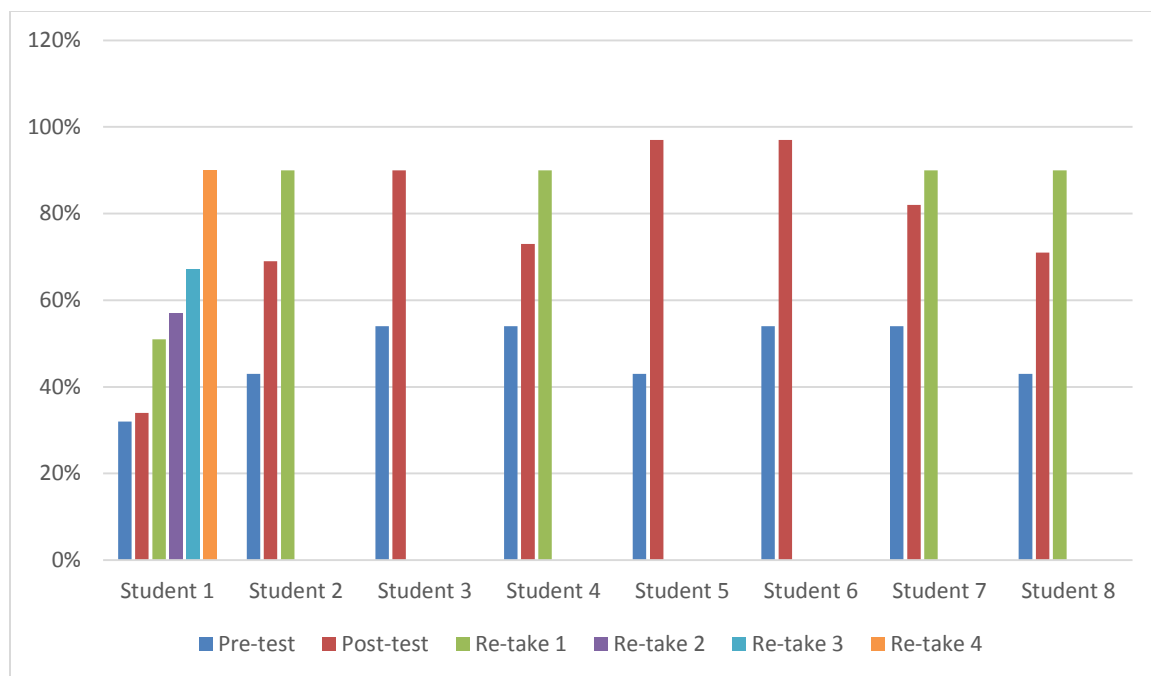
*Figure 9.* Comparison of post-test scores.

The students from 2013 had pre-test scores that were the lowest for both chapter one and chapter two and their post-test scores for chapter one were lower, but made the greatest gains compared with the other two groups for chapter two. The 2011 group, without the incorporation of mathematical projects, gained an average of 18% on their post-test scores for chapter one and an average of 28% on their post-test scores for chapter two. The 2012 group, without the incorporation of mathematical projects, gained an average of 34% on their post-test scores for chapter one and an average of 42% on their post-test scores for chapter two. The 2013 group gained an average of 45% on their post-tests for chapter one, without the incorporation of mathematical projects, and an average of 53% on post-test scores for chapter two, with the incorporation of mathematical projects. The comparison of average post-test gains from chapter one to chapter two was also the greatest for the 2013 group, who had an average post-test gain of 13%, while the 2011 group had an average 12% gain, and the 2012 group had no



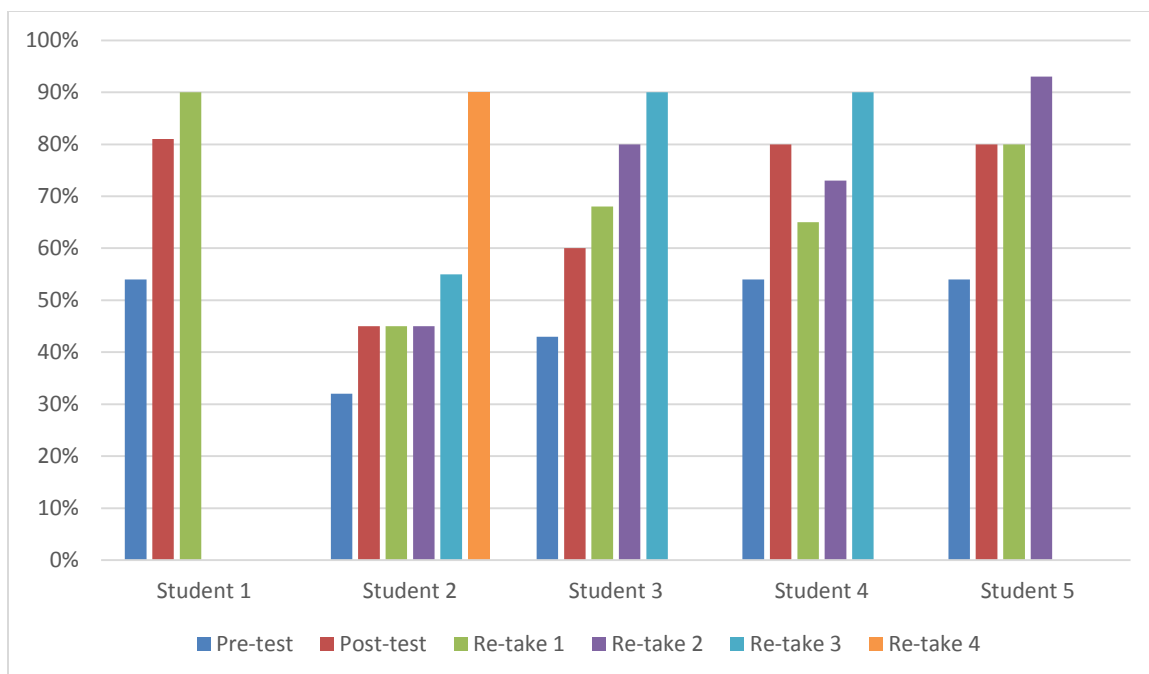
gains. After comparing chapters one and chapter two test score data, I believe the incorporation of mathematical projects into the mathematics curriculum does have a positive impact on the mastery of concepts gained by the seventh grade students.

After analyzing and comparing chapters one and two, I analyzed chapter three scores and compared them to chapters one and two, displayed on figures 10, 11, and 12.



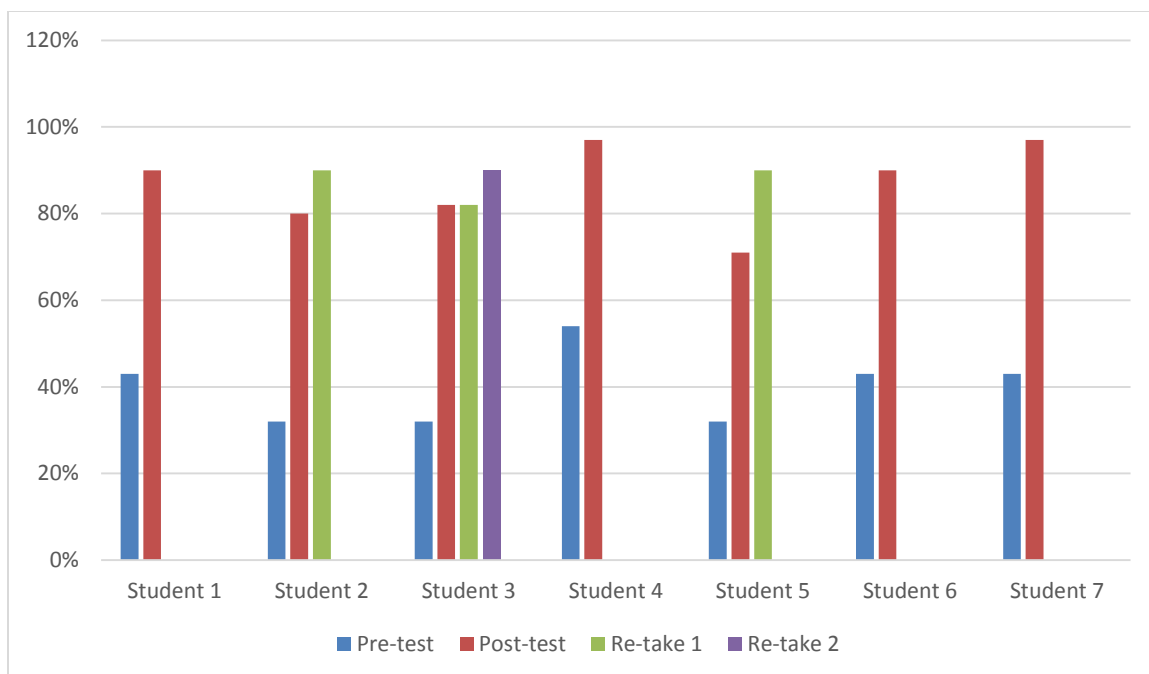
*Figure 10.* Scores for 2011 students, chapter three, without the incorporation of mathematics projects.

The average pre-test score for the 2011 students, chapter three, with no incorporation of mathematics projects was 47%, with a median score of 49%, a mode of 54%, and a range of 22%. The average post-test score was 77%, with a median score of 78%, a mode of 97%, and a range of 63%. The average number of re-takes to reach 90% + mastery was 1, with a median of 1, and a mode of 1.



*Figure 11.* Scores for 2012 students, chapter three, without the incorporation of mathematics projects.

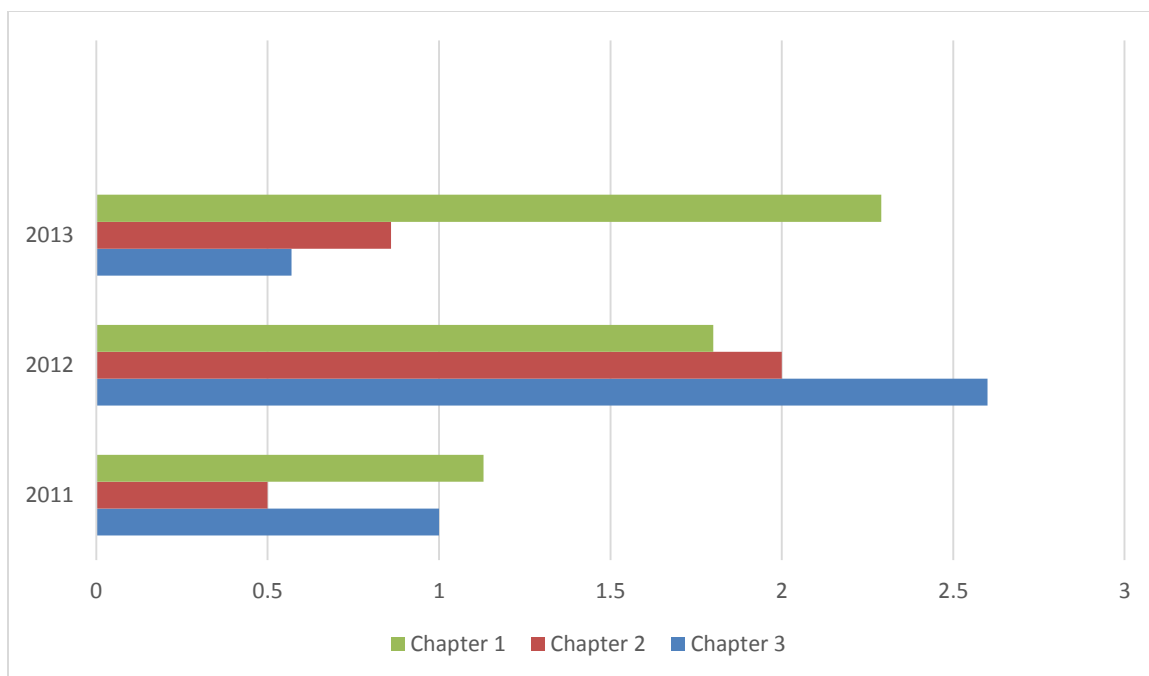
The average pre-test score for the 2012 students, chapter three, with no incorporation of mathematics projects was 47%, with a median score of 54%, a mode of 54%, and a range of 22%. The average post-test score was 69%, with a median score of 80%, a mode of 80%, and a range of 36%. The average number of re-takes to reach 90% + mastery was 2.6, with a median of 3, and a mode of 3.



*Figure 12.* Scores for 2013 students, chapter three, with the incorporation of mathematics projects.

The average pre-test score for the 2013 students, chapter three, with the incorporation of mathematics projects was 40%, with a median score of 43%, a mode of 43%, and a range of 22%. The average post-test score was 87%, with a median score of 90%, a mode of 90%, and a range of 26%. The average number of re-takes to reach 90% + mastery was 1.6, with a median of 1, and a mode of 1.

I then compared the average number of re-takes for students during 2011, 2012, and 2013, chapters one, two, and three. Figure 13 displays this comparison.



*Figure 13.* Comparison of the average number of re-takes for students during 2011, 2012, 2013, chapters one, two, and three.

In comparing each year's average number of retakes, the 2011 group decreased .63 times from chapter one to chapter two and then decreased .13 times from chapter one to chapter three. The 2012 group increased the average number of retakes .2 times from chapter one to chapter two and increased .8 from chapter one to chapter three. The 2013 group decreased 1.4 times from chapter one to chapter two and decreased 1.7 times from chapter one to chapter three. The two groups that had no incorporation of mathematics projects had fluctuating results, with the 2011 group decreasing the average number of retakes as the chapters progressed and the 2012 groups average retakes increased as the chapters progressed. The 2013 group, who had the incorporation of mathematics projects for chapters two and three decreased their average number of retakes the most.

Figures 14 and 15 display the comparisons of pre-test scores and post-test scores for all three groups after chapter one and chapter two.



*Figure 14.* Comparison of pre-test scores. *Figure 15.* Comparison of post-test scores.

These two comparisons show the highest average increase for both the average pre-test score, 18%, and the average post-test score, 20%, for the 2013 group of students that had the incorporation of mathematics projects in their curriculum. For two chapters, this 2013 group showed the greatest average gains on post-tests.

Before starting the mathematics curriculum with the seventh grade students in August of 2013, a Likert scale (see Appendix B) survey was used to gather information from the students about their thoughts on whether completing mathematical projects would help them learn mathematics concepts or not as well as their perception on their ability to obtain 90% + mastery on mathematics tests. This same survey was completed by the students after the chapter one test, before mathematics projects were incorporated into the mathematics curriculum, and after the chapter two and chapter three tests, after mathematical projects were incorporated into the mathematics curriculum. The data collected from these surveys was treated as ordinal. The survey results could then be put on bar graphs to analyze the average responses. The response choices were given values 1 – 5, with one assigned to “strongly agree” and five corresponding to “strongly

disagree”. Table 1 displays data for two of the survey statements with percentages of each response along with the number of responses in parenthesis. The two statements were chosen that emphasized the students’ thoughts and perceptions concerning their mastery of mathematical concepts, the main topic of this action research project.

Responses are shown for surveys pre chapter one, post chapter one, post chapter two, and post chapter three in Table 1.

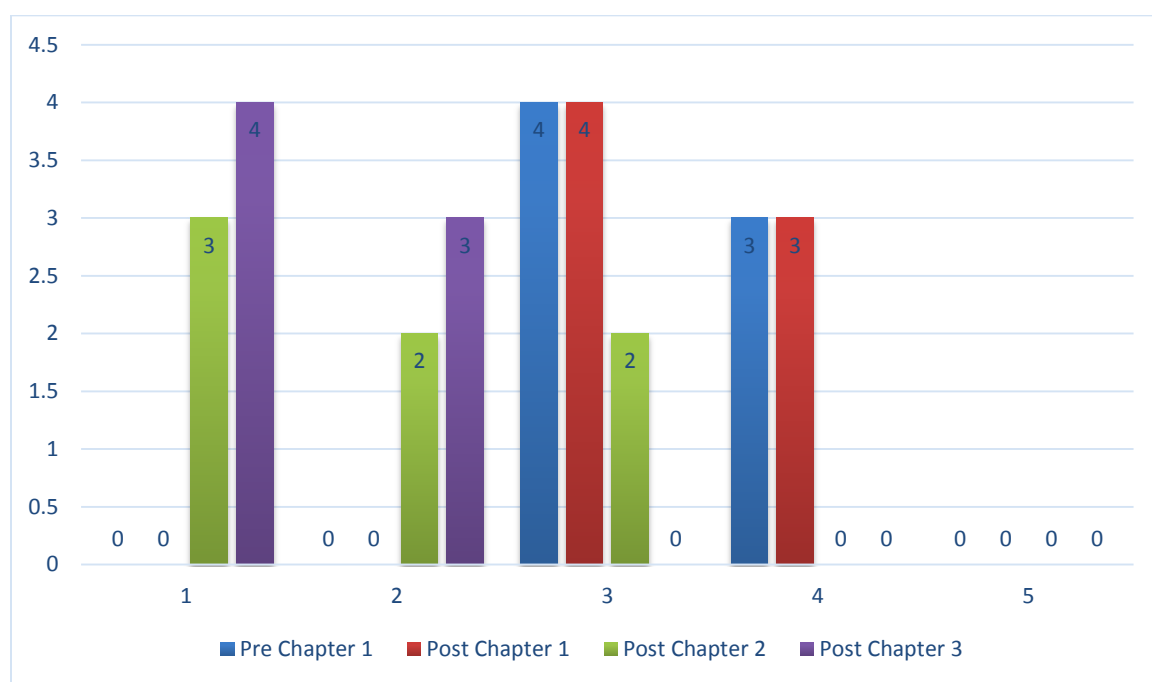
Table 1

Numerical, Percent, and Average Responses for Selected Survey Statements

		Strongly			Strongly		
		Agree	Agree	Undecided	Disagree	Disagree	Response
		(1)	(2)	(3)	(4)	(5)	Average
Completing and sharing a math project was valuable in helping me understand concepts in this chapter.	Pre Ch.	0% (0)	0% (0)	57% (4)	43% (3)	0% (0)	3.43
	Post Ch. 1	0% (0)	0% (0)	57% (4)	43% (3)	0% (0)	3.43
	Post Ch. 2	43% (3)	29% (2)	29% (2)	0% (0)	0% (0)	1.86
	Post Ch. 3	57% (4)	43% (3)	0% (0)	0% (0)	0% (0)	1.43
I am able to master mathematical concepts to 90%+ easily.	Pre Ch.	0% (0)	14% (1)	86% (6)	0% (0)	0% (0)	2.86
	Post Ch. 1	7% (.5)	21% (1.5)	43% (3)	29% (2)	0% (0)	2.93
	Post Ch. 2	0% (0)	14% (1)	57% (4)	29% (2)	0% (0)	3.14
	Post Ch. 3	14% (1)	57% (4)	29% (2)	0% (0)	0% (0)	2.14
Total						Participants	7

The average number of responses for students believing that completing and sharing mathematical projects was valuable in helping them to understand concepts in the chapter being studied was between undecided and disagree before starting any mathematics studies this year as well as after chapter one. As the students proceeded through chapters two and three, with the incorporation of mathematical projects, their average responses were closer to agree and strongly agree. These results parallel their average number of re-takes decreasing with the incorporation of mathematical projects.

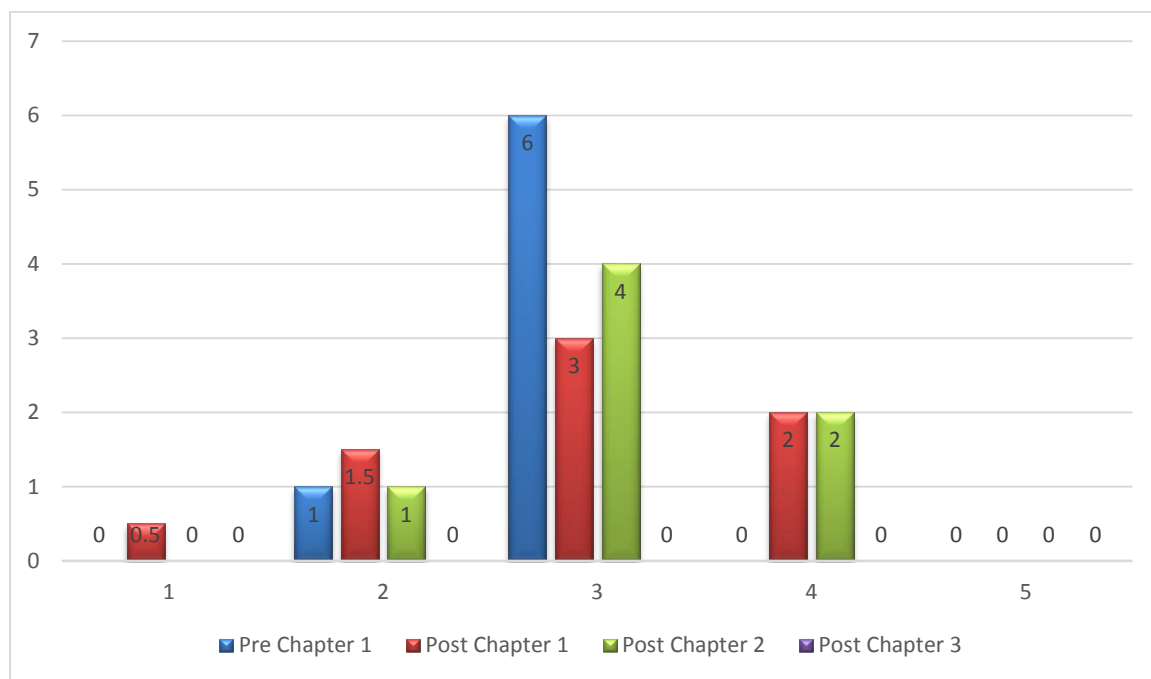
The number of students' responses versus the response choice for each statement are shown on Figures 16 and 17.



*Figure 16.* Degree to which students felt completing and sharing mathematics projects was valuable in helping them understand mathematical concepts.

The average of student responses went from 3.43, closer to undecided, before chapter one, and stayed the same after chapter one. After chapter two when mathematical

projects were incorporated into the curriculum, they answered closer to agree and strongly agree.



*Figure 17.* Degree to which students felt they were able to master mathematical concepts to 90% + easily.

Before chapter one, the majority of students were undecided if they could reach mastery of mathematical concepts to 90% + easily. This trend continued after chapter one, and chapter two.

Before chapter one students were undecided about both mathematics projects helping them understand mathematical concepts as well as whether they believed they could master concepts to 90% + easily or not. After chapter one, more students started to lean toward believing mathematical projects helped them understand mathematics concepts, but were still undecided about whether they could master mathematical concepts to 90% + easily. After mathematical projects were introduced into the curriculum, after chapter



two, the majority of students believed the mathematical projects helped them to understand mathematics concepts, but the majority were still undecided if they were able to master mathematical concepts to 90% + easily.

As I conducted daily observations and narratives, I looked specifically for students' daily attitudes while participating in mathematics, students' daily preparedness (homework complete, supplies ready), whether I had to approach the student vs. the student initiating meeting for math, the number of questions a student asked for further clarification, and the students' comments regarding the mathematics projects. Before incorporating the mathematics projects into the curriculum, chapter one was introduced to the students. The attitudes of the students were mixed. Of the seven, one student's attitude was negative on a daily basis, actually verbalizing, "I hate math." several times during math presentations each day. The other six students were excited to be working from a math text book. In the upper elementary classroom the students used the Montessori manipulatives for the majority of mathematics activities. Three students commented on how easy math was going to be this year. While working on chapter one together, all of the students had assignments completed on time, every day. Students were expected to bring their mathematics text, spiral, calculator, notecards, and a pen to the group meeting each day. The majority of students brought all of the necessary supplies daily, but one student regularly came with something missing, thinking the entire group would wait until they were prepared, stopped this after two weeks, as the rest of the group continued on and the students had to catch up on their own time. Three of the seven students asked on a daily basis when the math group would be meeting, even though we met at the same scheduled time each day. The other four students had to be

invited daily. The students that displayed a daily negative attitude was always the last one to join the group. Only two students regularly asked questions for clarification. The other students verbalized, “I know it all” or “I figured out the ones I got wrong” when I inquired about any unclear concepts. Without the incorporation of mathematical projects the average number of re-takes to reach 90%+ mastery was 2.29.

As chapter two was introduced, the observations noted above continued, however, four of the students were now asking for clarification regularly. It was during this chapter that the incorporation of mathematics projects started. Six of the seven students expressed great interest in reading through all of the choices, making a commitment to one project, and working on their projects and their presentations throughout the chapter. The student that had the generally, negative attitude had a difficult time making a commitment to a project, but did choose midway through the chapter, when given the deadline. When projects were presented, six of the seven were very enthusiastic to present. The student that had difficulty committing to a project, displayed a lethargic attitude, stating, “I’m sorry, mine is stupid, but here it is”. With the incorporation of mathematical projects, the average number of re-takes decreased from 2.29 to .85, with one student taking the same number of re-takes to reach mastery of 90%+ for chapter two as it did for chapter one. The other six students all decreased their number of re-takes for chapter two from chapter one. The student with the negative attitude decreased the number of re-takes by 66%.

During chapter three, one student chose to move through the chapter at a quicker pace, completing extra lessons during the weekend. That student presented the mathematical project early and decreased from two re-takes during chapter one, with no incorporation

of mathematical projects to one re-take before mastering chapter two to 90%+. The other six students all completed the minimum assignments on time and came to the mathematics lessons with all of the required supplies. All students asked more questions for clarification than during the previous two chapters. All of the students' attitudes during math were positive, including the student that previously displayed a negative attitude. Three students commented that they were excited to share their mathematics projects with the other students. The students' number of re-takes from chapter one to chapter three all went down except one student had the same number of re-takes. All of these data appears to support that the incorporation of mathematical projects into the mathematics curriculum helped students to understand and master mathematical concepts. Not only did the number of re-takes decrease, but observed attitudes and excitement toward mathematics increased.

After seeing the positive effects of incorporating mathematical projects involving real-world situations into the mathematics curriculum on student's mastery of mathematical concepts in a Montessori middle school program, I have devised an action plan to continue this process. In the following section I explain how I plan to incorporate more mathematical projects and more parent education into the mathematics curriculum.

#### Action Plan

The main focus of this action research study was to find out if the incorporation of mathematical projects in the seventh grade Montessori mathematics curriculum would have a positive, negative, or no effect on the students' mastery of mathematical concepts. The data and results of this study suggest that the incorporation of these projects had a positive effect on the students' mastery of mathematical concepts. Not only did the

students who did projects decrease, on average, the number of re-takes it took to reach the minimum 90% mastery on post-tests as compared to when they did not do projects and to the previous two years' groups of students that did not have the benefit of the incorporation of mathematical projects in their mathematics curriculum, but their gains from pre-test scores to post-test scores were greater than the previous two years' groups of students that did not have the benefit of the incorporation of mathematical projects in their mathematics curriculum. The trend of student excitement for mathematics escalating after mathematics projects were presented was observed and recorded during the collection of daily field notes that were turned into narratives. This trend supports that the incorporation of mathematical projects had a positive effect on the students' attitudes toward mathematics, possibly causing them to make better connections to the mathematical concepts, which effected their ability to master the mathematical concepts quicker than without the projects incorporated. Every student expressed enjoyment in working on and presenting their mathematical project. Another trend observed in the daily field notes and narratives was that 86%, six of seven, of the students, when given the opportunity, chose not to work ahead of the rest of the group. The six students that chose not to work ahead, chose to complete their daily mathematics assignments in class, as a group. They often discussed, among themselves, how they arrived at their answers. Rarely, did they ask for the input of the teacher. These students also expressed that because their homework was done, they could spend more time on their mathematics project at home. The student that worked alone was content working individually and expressed a need to have it quiet when doing mathematics work. This one student indicated extra time was available to work ahead. These trends of heightened excitement

for mathematics, an enjoyment in working together, and keeping a realistic pace also support the results indicating that incorporating mathematical projects is worth the extra time it takes to complete chapters in the mathematics text book as greater mathematical concept understanding was achieved, on average, by the students'. The survey responses also indicate that the incorporation of mathematical projects increases gains in mathematical concept mastery for middle school students. After completing and sharing the mathematical projects, the average responses to: "Completing and sharing a math project was valuable in helping me understand concepts in this chapter." and "I am able to master mathematical concepts to 90%+ easily." Moved closer toward strongly agree and agree. The data collected suggests that the incorporation of mathematical projects into the curriculum helped students to focus their time on completing and understanding work activities, as well as to believe their own understanding to be greater, which led to actual greater understanding of mathematical concepts.

These positive results indicate that including these mathematical projects should continue throughout the completion of the seventh grade mathematics curriculum and then, in the eighth grade mathematics curriculum, so that higher mathematical concept understanding can continue. I plan to continue this inclusion. I also plan to include more parent education time to cover the importance of not just getting through the math text book in order to be prepared for future math programs and also how mastering the mathematical concepts by tying them to real-world problem solving projects is beneficial for students' concept mastery. This parent education will help to alleviate unrealistic, parent imposed expectations and allow the students to move at a pace that is comfortable for them to be able to gain mastery of the mathematical concepts.

In the future, I would be interested in studying the effects of incorporating more involved, hands-on, projects involving mathematical concepts into the mathematics curriculum. In this study the students were able to choose from several mathematical projects, tied into real-world problem solving, offered in the mathematics text book. In the future I would like to have students come up with their own projects. For example, they might choose to do a construction project involving measurement when studying standard units of measure. Through my observations I saw the students' excitement and enthusiasm toward mathematics work heighten when allowed to work with partners or in small groups. In the future, I would also like to try having students work on the mathematical projects with partners or in small groups, in addition to just their regular daily assignments. I believe they would be able to challenge each other to an even deeper level of study if they had to communicate and explain their thought processes for solving problems to each other while working on the projects.

As the students become more excited about the subject of mathematics through making real-world connections, they are more likely to spend more time studying and pay closer attention to the information they are learning. Putting quality energy into the learning process will be seen in the gains of students' concept knowledge, not only through higher test scores, but through the completion of and presentation of mathematical projects displaying applied knowledge of understanding real-world problem solving. These student accomplishments will help both the students and their parents to see the importance of quality over quantity in work.

The conclusion of a positive effect of the incorporation of mathematical projects in the mathematics curriculum on students' concept mastery was based on data that was

collected during the completion of only three chapters of the mathematics text book.

There are thirteen chapters in the text book. I would be interested in following the trends during the completion of the text book to see if they remain constant and in support of the incorporation of mathematics projects. I would also like to follow the trends as the students continue into the eighth grade algebra curriculum and then follow up with their high school mathematics placement as freshmen.

It is my goal to expand this idea of shifting the focus to quality over quantity, as well as making as many real-world connections for students between the curriculum and their personal lives to not only the curricular area of mathematics, but to all curricular areas. I challenge myself and my students to expand the scope of knowledge from just text books to the endless connections that can be explored.

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## Appendix A

2013-2014

Dear Parents:

Your middle school student will be working in *The University of Chicago Mathematics Project Transition Mathematics* textbook this year. Each night your middle school student will be expected to read the assigned lesson, create a note card with pertinent information from the reading, and answer **only** the *Covering the Reading* questions. This assignment typically takes 30 minutes to complete. We will be reviewing that information together as well as completing the *Applying the Mathematics, and Review* questions in class, together. This will allow students to discuss challenging questions with each other as well as with me. If a student wishes to explore the math concepts further, they may go above and beyond by completing the *Exploration* section at the end of each lesson. This should be completed after we have done the rest of the lesson together and reviewed the answers. After chapter 2, the students will be completing the entire lesson independently as well as choosing a math project that incorporates the concepts covered in the chapter. The details for this assignment will be discussed with the students around the second week of September. Each student will create a calendar with assignment due dates. This calendar is a useful communication tool so that everyone is on the same page as far as when assignments are due and when quizzes and tests will be taken. It will be important for the student to ask questions whenever clarification is needed. If you have any questions or concerns, please let me know. As a part of a Master's program through St. Catherine's University, I will be collecting data to answer the question: What are the effects of incorporating math projects involving real-world situations into the math curriculum on student's mastery of math concepts in a Montessori middle school program. I am asking permission to allow your child's data to be collected and analyzed as a part of this project. All information will be kept anonymous and confidential.

Thank you,

Ms. Gwen

I, \_\_\_\_\_, give permission for my child's data to be collected and analyzed

(parent's signature)

as a part of Gwen Harris's Action Research Project for her Master's program through St. Catherine's University.

\_\_\_\_\_  
(date)

Appendix B

**Student Understanding of Mathematical Concepts Survey**

Student #: \_\_\_\_\_ Date: \_\_\_\_\_

Please respond to the following statements by drawing a circle around the response that most closely represents your opinions right now.

Key: SA – Strongly Agree

A – Agree

U – Undecided

D – Disagree

SD – Strongly Disagree

1. Independently creating a note card from the lesson reading helps me isolate math concepts that will be focused on in each lesson.

SA          A          U          D          SD

2. Independently completing the *Covering the Reading* questions helps me solidify mathematical concepts in my mind.

SA          A          U          D          SD

3. Completing the *Applying the Mathematics* questions and the *Review* questions in class with the group helps me understand the mathematical concepts covered in the lessons.

SA          A          U          D          SD

4. Discussing troubling questions with classmate is helpful in my understanding of the mathematical concepts being covered in the lessons.

SA          A          U          D          SD

5. Making corrections on math quizzes helps me know what mathematical concepts I need to devote more time to in order to understand them.

SA          A          U          D          SD

6. Completing optional *Exploration* questions was valuable in helping me to understand mathematical concepts in each lesson.

SA      A      U      D      SD

7. Correcting tests that I did not attain mastery (90%+) on was helpful in understanding mathematical concepts before retaking tests.

SA      A      U      D      SD

8. Completing and sharing a math project was valuable in helping me understand concepts in this chapter.

SA      A      U      D      SD

9. My mathematical concept understanding improved after completing the chapter lessons.

SA      A      U      D      SD

10. I am confident that I will use mathematical concepts learned in the real world.

SA      A      U      D      SD

11. I am moving at a comfortable pace in math in order to understand the mathematical concepts being introduced.

SA      A      U      D      SD

12. I would like to move faster through the math curriculum.

SA      A      U      D      SD

13. I would like to move slower through the math curriculum.

SA      A      U      D      SD

14. I am able to master mathematical concepts to 90%+ easily.

SA      A      U      D      SD