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Multiplication Fact Fluency and Multiple Intelligences in a Third Grade Classroom

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Abstract

The purpose of this quasi-experimental study was to examine if teaching students their multiplication facts in a way that utilized their multiple intelligence strength would be a more effective way of teaching students their multiplication facts than having students learn their multiplication facts through rote memorization only. All four groups who received a teaching of multiplication facts intervention made gains in learning their multiplication facts. The three multiple intelligence groups did make more gains in learning more facts, than the one group who only learned their facts through rote memorization. However, the rote memorization group was able to give more facts automatically in the post assessment when compared with the other three multiple intelligence groups.

Review of Literature

How Do Children Best Learn Math Facts ?: A Literature Review

Math fact fluency in the elementary years is extremely important. Students need to be fluent in knowing their addition, subtraction, multiplication, and division facts. Fluent means they can accurately and automatically recall the answers to all their math facts. Burns et al. (2015) found that students who were fluent in their math facts, had more time and energy to spend on the demands of problem solving. If students are unable to master their math facts, they have to work much harder and longer on more complex math problems. This can cause frustration and makes more complex math problems more difficult to solve. It can even lead to children developing a dislike for math (Boaler 2015).

Review of Literature

Teaching Children Math Facts Through the Use of Technology

Musti-Rao and Plait (2015) found that in order to improve learning for all students and increase instructional efficiency, teachers need interventions that can be applied class wide or to large groups of students, but at the same time differentiate instruction by providing an appropriate level of challenge for each student. If a school has computer devices for each student, that computer device may be used to give students that individualized instruction. Multiple studies involved children learning their facts using technology. Researchers found that children really enjoyed using technology, such as an iPad or laptop, to learn their math facts. (Berrett & Carter, 2018; Caviola, Gerotto, & Mammarella, 2015; Musti-Rao, & Plati, 2015; Nelson, Burnes, Kanive, & Ysseldyke, 2013) In multiple studies, children were asked to take a pre-test to see how many math facts they knew, they practiced their math facts using a computer app for a certain period of time, and then took a post test to see how many more math facts they

knew after using the app. Berrett and Carter (2018) found that using technology, many of the recommended and effective practices intended to improve math fact fluency such as modeling, drill and practice, immediate and regular feedback, and adaptive individualized presentation were able to be accomplished by the technology device.

Teachers have reported they liked using technology because it could be differentiated for each student, it was easy to use, and the children enjoyed the practice time. Nelson, Burns, Kanieve, and Ysseldyke (2013) found that the inherent flexibility of technology-based practice interventions allows for individuals, small group, or classroom application- something that stands in contrast to similar interventions that may require more time and personnel as the number of students increase. Students were able to make more responses using the technology involved with iPads or desktops and students assigned to the iPad practice-base intervention groups tended to produce higher fluency scores relative to students assigned to the control group.

Shobana and Plati (2015) found that students showed a steady increase in the number of math facts they practiced during each of the intervention sessions, making twice as many responses in the iPad intervention when compared to a Detect, Probe, Repeat, (DPR) practice worksheet. Students liked being able to tap a screen or click an answer more than writing out their facts on a paper with a pencil. Because of these factors, students who learned their math facts using technology were able to learn more math facts.

Teaching Children Math Facts Rote Method

Another way children can learn math facts is through repeated practice using a paper and pencil procedure. Several studies reviewed involved children learning their math facts through rote memorization of some kind. There seem to be many paper and pencil methods of teaching math facts. A pretest is given before the intervention begins, the paper pencil intervention is

given, and then a post test is given to track student progress. All the paper pencil methods involve the child writing out the math facts as a way of learning them. Researchers in these studies have shown that repeated practice using paper and pencil practice, writing out math facts repeatedly, helps students achieve fluency, and the ability to retain what they have learned. Some math facts require more repetition to learn than do others, and students at younger grades or with math difficulties may require more repetition that students in older graders or with higher math skills. (Burns, Nelson, Ysseldyke, and Kanive, 2015; Schutte, et al., 2015)

Teaching Children Math Facts by Playing Games

Another way to teach children math facts is by having them repeatedly play math games involving math facts. In this way, children are learning their math facts in a way that is not timed and is not done by having students memorize facts by either repeatedly writing them or typing them on a computer screen like the previous two methods. Boaler (2015) found that mathematics facts are important, but the memorization of math facts through times table repetition practice and timed testing is unnecessary and causes math anxiety. By having children play math fact games, they develop number sense. According to Boaler (2015), number sense is a person's ability to use and understand numbers. The researchers of these studies provided various games that focused on understanding the mathematical operations rather than just memorizing the facts. The games often included hands on materials and discussions. Godfrey and Stone (2013) found when students played math fact fluency games, students focused on higher-level thinking strategies and by discussing them with a partner, this caused their fluency and number sense to increase.

Conclusion

Poncy, Fontenelle, and Skinner (2013) found that many students in our country do not know their math facts, addition, subtraction, multiplication, and division. This lack of math fact mastery has led to students struggling with more complex math problems and math frustration. The goal of this literature review was to research what is the best way for students to learn their math facts. Through this literature review, three main ways of teaching math facts have become clear. The first and second ways are by repeated practice whether it is on a computer or by paper and pencil. The third way is by playing math fact math games that involve students developing a strong number sense through discussion and hands on materials. All three ways work in the research. The repeated practice using computer technology seems to be the easiest for teachers to use, the most differentiated, and the favorite among students. The repeated rote practice also worked, was very popular, and can be done in various ways. The way of playing math games seems to focus more on students understanding the math facts, retention of math facts and not on just memorization of facts.

These methods were all shown to work, but none of them looked into the fact that children are all individuals with individual multiple intelligence strengths that could be used to help them learn. Multiple Intelligence is way of looking at human intelligence. In this view of intelligence, Gardner (2011) found that humans are intelligent in many different ways, and each type of intelligence is correlated to a specific area of the brain and corresponds with certain personal skills and preferences. Teachers have always known from their own teaching experiences, that students learn in different ways, and Gardner's Multiple Intelligence (MI) Theory supports their own classroom experiences. Traditionally, schools have been designed for students who are mathematical and linguistic, not for students who are artistic, musical or

kinesthetic learners. If educators can recognize that students learn in different ways, they can design learning activities that involve student strengths. The result of this will be more engagement and, therefore, more learning for students.

Research Purpose/Question

The purpose of this study was to examine if teaching students their multiplication facts in a way that utilized their multiple intelligence strength would be a more effective way of teaching students their multiplication facts. Does this method of teaching students by utilizing their multiple intelligence strength, improve a student's ability to learn their multiplication facts more effectively than a more traditional rote memorization method?

Methods

This was a quasi-experimental design study. Specifically, a group of eight and nine-year-old children in a third-grade classroom were surveyed to find each student's multiple intelligence strength. The survey was found and shown to the students' third-grade classroom teacher to make sure it was age appropriate or if she thought they would have any trouble reading it. It was reviewed and edited to remove formal language, so the students were better able to understand it (See appendix A). Help was given to any students who needed help reading any of it when the survey was given. Each of the statements on the survey were read aloud to the students one at a time so that they could ask any clarifying questions they had. The students wrote in their numbers for each statement on the survey. They filled in each number for each statement one at a time. Their classroom teacher had reported that they do a zero-five scale each day for their daily behavior goal, so they were very familiar with the zero-five system of rating things that was used in the survey.

From that survey, three multi-intelligence-based groups were formed. The multiple intelligence strength groups were: musical-rhythmic(five students), visual-spatial(four students), and body-kinesthetic group(four students). All eight multi-intelligence groups were not formed because not all of them fit with teaching multiplication facts. A fourth group was also formed that would learn their math facts only through rote memorization (See appendix C for an example of the rote memorization worksheets).

A math running record was given to each of the students in the class before the intervention was started, to determine how many multiplication facts they already knew and how many they didn't know. See appendix B for the multiplication running record sheet. The students were then separated into the four groups(three multi-intelligence groups and one rote memorization group). Each group received the math intervention for ten minutes per day during their math block period, Monday-Friday. Learning multiplication facts is a required standard for third grade in this school, so learning multiplication facts was something the class would normally be doing even if this intervention were not being done.

During the first two weeks of his experiment, all four groups of students started learning their multiplication facts in a very traditional manner, rote memorization. Specifically, all four groups were given multiplication fact practice worksheets for them to complete and the students practiced their multiplication facts by writing out their multiplication facts repeatedly. See appendix C for multiplication worksheet example. How many math facts each student learned was tracked by giving them a formative, untimed, mixed, biweekly, multiplication facts quiz. The biweekly assessment was one the classroom teacher routinely used and took less than 3 minutes to complete. The results of this biweekly quiz were used to form instruction for the next week and to see if there was a difference in the amount of facts learned between the multiple

intelligence groups and the rote memorization group. This was done throughout the experiment. See appendix D for the math facts quiz.

After two weeks of having all students do the repeated rote learning of multiplication facts, three of the four groups started learning their multiplication facts through the multiple intelligence strength math interventions. The study was started in this way so that students in the three multiple intelligence groups could see how different it was to learn their facts from just writing them out to the activities they were doing in the multiple intelligence groups. Examples of how students were taught their multiplication facts utilizing the students' multiple intelligence strength are shown in Table 1.

Table 1

Multiple Intelligence Group Activities

Visual-Spatial	Drew and created arrays, drew groups of objects, made area models, and wrote out repeated addition for each multiplication fact in all of the times tables to get a good visual for each fact.
Musical-Rhythmic	Watched multiplication rap videos for each times table and the group was given a multiplication song sheet that went with a well know song. Each day the group watched the multiplication rap video and also sang the multiplication fact song together multiple times.
Body-Kinesthetic	Built each fact with hands on manipulatives such as Legos and adding groups of marbles into egg carton containers. Wrote out their facts on pieces of card stock which they laid out in the hallway like a hopscotch game. They then hopped from fact to fact saying the fact as they went. They also put their multiplication fact cards in a line next to each other and hopped next to each other saying their facts as they hopped on their cards as a race to see who could say their facts first.
Rote Memorization	Filled in one multiplication fact practice sheet each day in class.

Then after the six-week intervention period, a multiplication running record was again given to each student in the class to see what growth each student had made in learning their multiplication facts as a result of this intervention.

The results of the students who were taught their math facts in a way that utilized their multiple intelligence strength was compared to the students who continued to learn their multiplication facts through rote multiplication only. This was done to see if the multiple intelligence groups had more growth than the group that learned their multiplication facts by just writing out their multiplication facts. Comparisons were made to see how many multiplication facts each student learned individually, and then each group learned, before and after the math intervention was done. How many multiplication facts each individual student, and then each group learned to automaticity, was also completed.

Site

This study took place in York County in Southern Maine at Waterboro Elementary School which is located in Waterboro, Maine. This elementary school is one of five elementary schools in RSU 57. The school has a total population of 557 students in grades PreK-grade five. The school has 42% of its students receiving free or reduced school lunch. Waterboro Elementary School has 22.8% of its students receiving special education services. The school does receive Title I funding. It has two reading specialists and two math specialists who implement tier three interventions, and four education technicians who teach push in support of Tier two plans in the classrooms.

The participants of this study were one of the four, third grade classrooms at Waterboro Elementary School. Seventeen students in the class participated in the study. The students were

all either eight or nine years old. One student joined the study eleven days after the study began because she had just move into the school district and had just joined the class.

Informed consent letters explaining the study, participate requirements, risks, benefits, and confidentiality were sent to parents (Appendix F). Written consent forms were also read to and obtained from each student who participated in this study (Appendix E).

Instruments

Multiplication Running Record Assessment by Newton (2016; Appendix B) was used as my pre and post assessment. The biweekly informal multiplication fact quizzes and rote memorization group practice worksheets were worksheets that the teacher has had and used for many years (See appendix D). After reading about the characteristics of each multiple intelligence groups strengths, I found activities that corresponded with each strength by searching the internet and my teacher files.

The Musical-Rhythmic multiple intelligence group used multiplication raps that came from the website Focabulary (https://www.flocabulary.com/topics/multiplication-division/) and the multiplication songs were from the Teacher's Pay Teachers website (See appendix G). The Visual Group used the Multiplication Fact Box worksheets (See appendix H). I also had my visual group use manipulatives such as math tiles to make arrays so they could visually see the math facts they were learning. The Kinetic-Body Group used Legos, marbles, egg cartons, cardstock, and markers to learn their facts.

Procedure

This study began in December 2019. It began by giving each child a multiplication running record as a pre-assessment. The running records were scored for each child and stored to be able to compared with my post assessment data. Before each multiplication running record

was given, the project and consent form was read and explained to each student. Each student was asked to sign the consent form if they wanted to, and all the students consented to being in the study and signed the forms. A parent consent form was given to each student to bring home, ask their parent to sign, and bring back to school the next day. Seventeen out of eighteen students brought back their consent forms signed. One student did not bring back her parent consent form, and therefore could not participate in the study because parent consent was not given.

In December, the Multiple Intelligence Survey was presented to the class. Each statement was read aloud to the class and students filled in how they rated themselves. The surveys were tabulated and collected to that students could be assigned into multiple intelligence groups.

On the following Monday, each student was given a multiplication practice worksheet to fill out each day as part of their morning work. No instruction was given with the worksheet other than to complete it, and the answers to the multiplication problems were listed at the top in case the student did not know the answer and wanted to look up at the answer. Each day these were collected as the student finished them, and on Friday they were given the multiplication test for that times tables quiz. The percentage of correct responses were recorded.

At the beginning of week three of the intervention, the class was separated into four groups based on how the students answered their multiple intelligence surveys. They were separated into a Rote Memorization Group, a Visual Group, a Body-Kinesthetic Group, and a Musical-Rhythmic Group. An area with a table and chairs was set up outside the classroom so that groups could be pulled out for the math intervention. The rote memorization group continued to work on their worksheets in the classroom as part of their morning work. For the

other three groups, they were called out one at a time for approximately ten minutes per day for the math intervention. For each of the groups, activities were ready that utilized their multiple intelligence strength. Each group was presented with what multiplication table we were working on that week and what the multiplication strategy that went with that table was. This was repeated each day Monday-Thursday for six weeks. At the end of each week, the formative multiplication quiz was given.

At the end of the intervention, each student was again given the multiplication running record, so that their pre and post multiplication running record assessments could be compared to see what effect the intervention had on how many math facts they had learned.

Data Analysis

The data collected from this quasi-experimental study was used to determine if students would learn more multiplication facts if they were taught their multiplication facts in a way that utilized their multiple intelligence strength, than if they were taught through rote memorization only. Multiplication running records were used as a pre and then post assessment to determine if students in the multiple intelligence groups learned more facts than the group that learned their facts by rote memorization only. The multiplication running record has twelve specifically chosen multiplication facts for students to answer in the first part, a second part which focuses in on their learning of their multiplication strategies, and then a short math survey. The individual scores of each individual student were reported with the group they were in, and finally a percent was found for each group to show the amount of growth each group had in learning their math facts.

The amount of multiplication facts each student knew automatically out of the twelve facts on the assessment was also totaled as when you give the multiplication running record, the

recorder scores the student on whether they could give them math fact automatically, within five seconds (5s), or with prolonged thinking (pth). This was done to see the multiplication fluency of each student before and after the intervention. This data was also done for each group and the percent of growth for each group is shown. The students were not taught that they had to be automatic in their math interventions so being automatic was not stressed in the math intervention lessons, however, this data was collected to see if there was any difference in the automaticity of the students between their pre and post assessments.

Results

The following tables and graphs show the details of how many facts each student learned individually pre and post assessment. Then the results of how many math facts each group learned by percent is shown. The results are then presented again in the same way for how many facts each student, and then each group, learned to automaticity.

Table 2

The Amount of Multiplication Facts Each Student Learned From the Intervention

Student Number	Pre-Intervention Number of facts answered correctly	Post Intervention Number of facts answered correctly	Difference Between Pre and Post Interventions
Visual-Spatial Group			
1	0	4	4
3	10	11	1
7	4	7	3
10	1	8	7
Musical-Rhythmic Group			
6	9	12	3
9	5	5	0
14	1	12	11
17	5	12	7
18	11	12	1
Body-Kinesthetic Group			
2	7	11	4
5	5	12	7
15	10	9	-1
16	5	10	5
Rote Memorization Group			
8	6	9	3
11	2	9	7
12	11	12	1
13	7	6	-1

Table 2 shows the individual student scores for the amount of multiplication facts each student learned from the math intervention. Two students actually knew one less multiplication fact after the intervention than before the intervention, but overall most students improved in the amount of facts they knew after the intervention. Each of the groups had one student learn seven more facts after the intervention then before. The Musical-Rhythmic group had the students with the most growth. One student in that group went from knowing one fact on the pre running

record to knowing all twelve facts on the post running record. This table shows that the math intervention appeared to make a difference in the students learning their math facts. This becomes even more clear by looking at the percent of growth for each of the intervention groups shown in figure 1 below.

Figure 1

Percentage of Growth from Intervention for Each Group

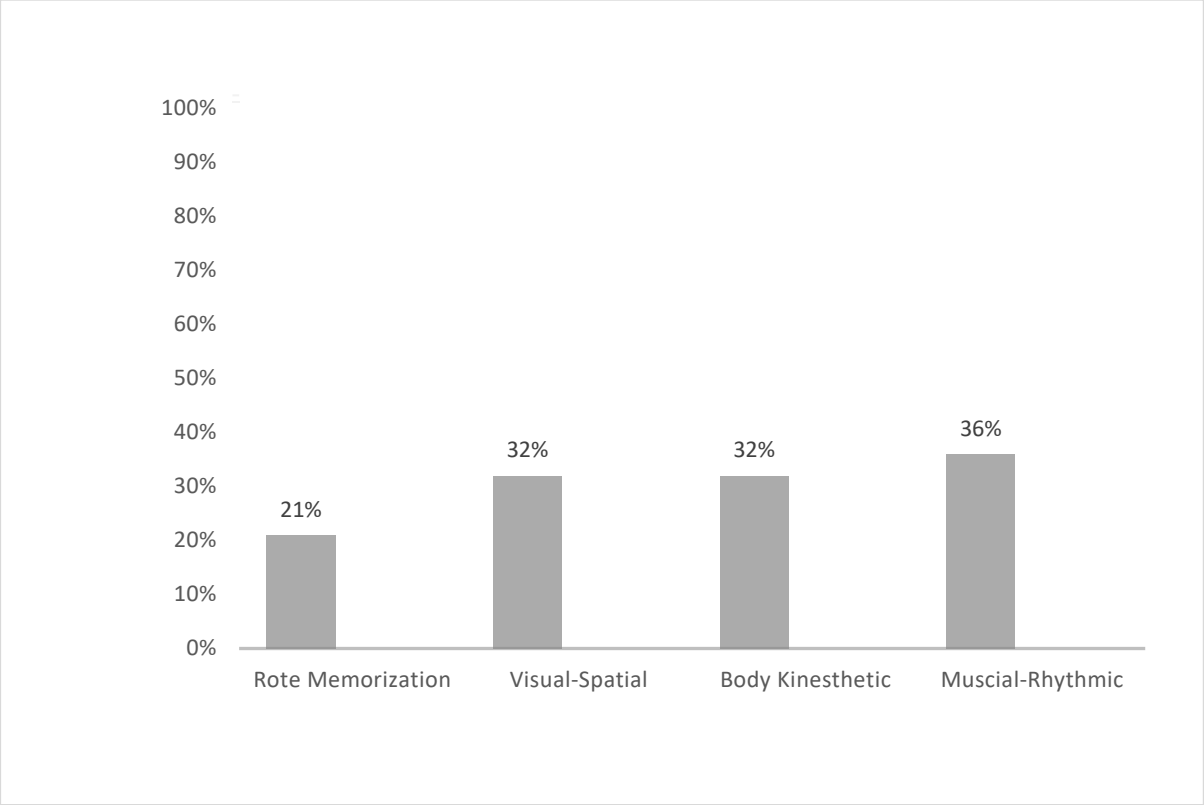


Figure 1 shows that students in the multiple intelligence groups did learn more multiplication facts than the students in the rote memorization group. The most facts were learned by the Musical-Rhythmic Group. They had a 36% growth in learning new facts, and the rote memorization group had the least amount of growth of new facts at 21% growth. So, the percent of growth between the Musical-Rhythmic group, which had the highest percentage of growth, and the Rote Memorization group, which had the lowest percentage of growth was 15%.

The mean of the three multiple intelligence groups was 32% growth while the rote memorization group had 21% growth. The difference between these two percentages shows the students in the multiple intelligence groups had 11% more growth than the students in the rote memorization group. This indicates that when students are taught in a way that utilizes their multiple intelligence strengths, they may learn more effectively.

Data was also collected in this study on the amount of multiplication facts each student learned to automaticity. Learned to automaticity means that a student could look at a multiplication fact written on a paper and give the answer to that fact within five seconds. If the student got the answer correct after five seconds, it was recorded as correct, but not done to automaticity. Table 4 shows each the amount of multiplication facts each student knew to automaticity before and after the math intervention was done.

Table 3

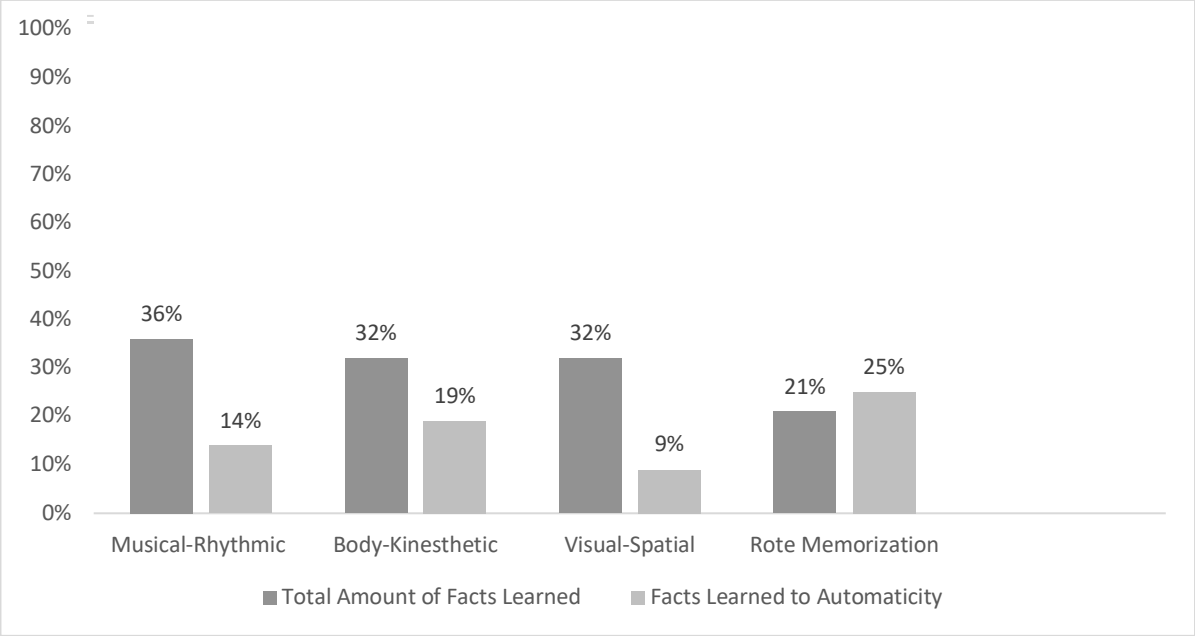
The Amount of Multiplication Facts Each Student Learned to Automaticity

Student Number	Pre-Intervention Number correctly answered	Pre-Intervention Number correctly answered	Pre-Intervention Number correctly answered
Visual-Spatial Group			
1	0	1	1
3	3	3	0
7	1	2	1
10	0	2	2
Musical-Rhythmic Group			
6	4	7	3
9	1	2	2
14	1	6	5
17	5	5	0
18	6	5	-1
Body-Kinesthetic Group			
2	2	5	3
5	5	5	0
15	3	7	4
16	3	5	2
Rote Memorization Group			
8	2	4	2
11	1	6	5
12	6	10	4
13	4	5	1

Table 3 shows the amount of facts each student learned to automaticity compared to how many facts the students learned, the amount of facts learned to automaticity was much less. One student learned one less multiplication fact after the intervention than before and three students learned did not learn any more multiplication facts after the intervention than before the intervention. This shows that this type of math intervention may not be as effective if teaching students to learn their multiplication facts to automaticity.

Figure 4

Percent of Growth by Group for the Amount of Multiplication Facts Learned and for the Amount of Multiplication Facts Learned to Automaticity



In looking at the percentage of growth by groups learning their facts to automaticity, the results were that the rote memorization group actually had the most growth at 25% and the visual-spatial group had the least amount of growth at 9%, with a 14% difference between the highest and lowest groups.

The mean of the multiple intelligence group growth for automaticity was 14% growth while the rote memorization group was 25%, with a 9% difference between the two groups. This shows that the students in the rote memorization group learned more facts to automaticity than the students in the multiple intelligence groups so if students want to be learn their multiplication facts to automaticity, rote learning will produce the most learning of facts.

In summary, the results of this study show that the students in the multiple intelligence groups learned more facts than the rote memorization group, however, the students in the rote memorization group learned more facts to automaticity than the multiple intelligence groups did.

Discussion

In this study, the effect of teaching third grade children their multiplication facts in four different ways was explored to determine if teaching students their multiplication facts in a way that utilized their multiple intelligence strength would be a more effective way to have students learn their multiplication facts than through rote memorization. A multiple intelligence survey was given to the class to determine which group each student should be placed into. The students were then placed into three different multiple intelligence groups (a visual-special group, a musical-rhythmic group, a body-kinesthetic group), and a rote memorization group. Specific activities were designed and taught to each group for a six-week math intervention. A pre and post intervention multiplication running record assessment was given to collect data on how many multiplication facts each student learned and how many multiplication facts each student learned to automaticity. The data was then compiled and is shown in the tables and figures of this study.

Limitations

One limitation of this study was students all had different background knowledge of multiplication. The students were not assigned by any other factors other than their multiple intelligence strengths. Some students in each group knew how to multiply, and some students had very little exposure to multiplication. For example, the background of each student or what students were doing with their parents at home could not be controlled. One student in the rote

memorization group was practicing her multiplication tables with flash cards with her parents at home, and some students had no practice going on at home.

Another limitation of this study was the amount of time that the study was able to be done in. The math intervention had to be done in the six-week time period. The results may have been different if the intervention time could have been longer.

The final limitation was that the participants were not randomly selected; they were selected based on their ability to participate in the study. The sample was convenient to the researcher and may not be a representative of the total population of third graders.

Implications for Practice

Given the study results, there are several implications for practice. When giving the post assessment for this study, the students were still using the strategies they were taught while taking their post assessment. For example, the musical-rhythmic group was singing the songs they had learned, the visual-spatial group was drawing arrays, pictures and sets, the body-kinesthetic group was in motion as they gave their answers. All of the multiple intelligence activities were not taught with speed in mind. So, it was not unexpected that those students did not have the most growth in automaticity but did have the most learning of facts. The group who had only practiced rote memorization was used to just knowing a fact and writing it down. They learned in a way that was pure memorizing from writing and seeing the facts, so that was very similar to the multiplication fact assessment they were given. Therefore, it was not unexpected to see that they had the learned the most multiplication facts to automatically.

From the data collected and displayed in the tables and graphs of this study, it can be concluded that the math intervention of teaching students to their multi-intelligence strengths appeared to make a difference in the amount of multiplication facts the students were able to

learn. In comparing the group of students who only learned their multiplication facts through rote memorization with the groups that learned their multiplication facts through a multiple intelligence strength, the data showed the students in the multiple intelligence groups learned more facts. The results showed the students in the rote memorization group actually improved the most in the number of facts known to automaticity. This may be because the assessment was most similar to the way they were learning their facts.

These results show that students should be taught what multiple intelligence is and be able to explore what their multiple intelligence strengths are, so they have the opportunity to strengthen ones they are weaker in, and utilize the ones they are stronger in. This could also be a reason that providing students choice is so important when they are learning. By providing students a choice as to how they want to learn and present their findings, they are allowed to utilize their multiple intelligence strengths in effective ways.

Implications for research

This study had to end because the intervention time had ended, but important information could be learned by doing a follow up assessment another six weeks or more after the post assessment to see if there is a difference in the amount of multiplication facts that each group retained. It would be interesting to see if the multiple intelligence groups were still using the strategies they were taught and had retained their facts, or had they forgotten them. Did one group have more retention of facts than the others? Have they become more automatic with their facts because they now have had time to practice them and become more proficient at them? It would be interesting to see if the rote memorization group still remembered the facts they had memorized, or did they forget them because they were no longer writing them out.

A result not shown in the data because it was unexpected, and so data was not collected on it, was the motivation and excitement to learn multiplication facts that was seen from the multiple intelligence groups compared with the rote memorization group. The multiple intelligence group students were waiting at the door for their math intervention time, while the rote memorization group would ask if they really had to finish the worksheets they were given. Four students who complete daily behavior charts because they routinely have a hard time following class rules, did not have even one problem with following class rules the entire six-week time of the intervention. This showed that allowing students to learn new material in a way that utilized their multiple intelligence strength was motivating to students. Since such positive behavior responses were noticed when teaching these groups, it would be an interesting study to track the behavior of students who are being taught in a way that utilizes their multiple intelligence strength versus those same students being taught in a way that makes using their multiple intelligence strength hard to use.

Conclusion

According to Berrett and Carter (2017) math fact fluency is foundational for later mathematics education. Students need to learn their math facts to help them be able to solve more difficult problems. The results of this study support the idea of teaching students using their multiple intelligences as often as possible. This study provides strong evidence that students do learn more multiplication facts when they are given the opportunity to learn them in a way that utilizes their multiple intelligence strength. It is recommended that more research be conducted to determine if teaching multiplication facts in a way that utilizes multiple intelligence strengths will help students to retain more multiplication facts, if teaching in this way could be applied to teaching many other subjects, or if it makes a difference in student behavior in class.

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Appendices

Appendix A

Multiple Intelligence Survey for Children

Getting To Know You Survey

Name _____

Directions:
Fold this paper on the dashed vertical line so that the eight columns on the right are folded back. Then read each statement below as Mrs. Nugent reads them aloud to you. Rate it from 0 to 5 according to how well the description fits you (0= Not at All to 5 = Very True).
Please raise your hand if you don't understand any of the statements and Mrs. Nugent will explain it to you. Next unfold the survey and write each number on the outlined block on the same row.
If you have trouble placing the numbers in the column or adding up the numbers in the column, raise your hand and a Mrs. Nugent will do it up for you.

Which of the following are true about you?	**0-5**	Naturalist	Mathematical - Logical	Verbal - Linguistic	Musical - Rhythmic	Visual - Spatial	Bodily-Kinesthetic	Interpersonal	Intrapersonal
I find myself singing or humming many times during the day.					☐				
I love crossword puzzles and other word games.				☐					
I like spending time by myself.									☐
Charts, maps, and graphic organizers help me learn.						☐			
I learn best when I can talk over a new idea.								☐	
I enjoy art, photography, or doing craft projects.						☐			
I often listen to music in my free time.					☐				
I get along well with different types of people.								☐	
I often think about my goals and dreams for the future.									☐
I enjoy studying about the earth, weather, and nature.		☐							
I like learning about animals and taking care of pets.		☐							
I love projects that involve acting or moving.							☐		
Written assignments are usually easy for me.				☐					
I can learn new math ideas easily.			☐						
I play a musical instrument (or would like to).					☐				
I am good at physical activities like sports or dancing.							☐		
I like to play games involving numbers and logical thinking.			☐						
My best way to learn is by doing hands-on activities.							☐		
I love painting, drawing, or designing on the computer.						☐			
I often help others without being asked.								☐	
If given a choice, I'd much rather be outside than inside.		☐							
I love the challenge of solving a difficult math problem.			☐						
Having quiet time to think over ideas is important to me.									☐
I read for pleasure every day.				☐					
Totals	→								
		Nature	Math	Word	Music	Art	Body	People	Self

Adapted from *MI Theory for Kids Survey* from Laura Candler ~ www.lauracandler.com

Appendix B

Multiplication Running Record

MULTIPLICATION RUNNING RECORD	
Student Page	
0 x 4	4 x 8
1 x 2	6 x 7
5 x 3	4 x 4
10 x 7	7 x 8
2 x 6	8 x 5
3 x 9	9 x 6

Part 1: Multiplication Running Record Recording Sheet Strategy Levels and Accuracy			
0 x 4	a ca sc asc fco/skf coh pth dk	M0	0 1 2 3 4
1 x 2	a ca sc asc fco/skf coh pth dk	M1	0 1 2 3 4
5 x 3	a ca sc asc fco/skf coh pth dk	M5	0 1 2 3 4
10 x 7	a ca sc asc fco/skf coh pth dk	M10	0 1 2 3 4
2 x 6	a ca sc asc fco/skf coh pth dk	M2	0 1 2 3 4
3 x 9	a ca sc asc fco/skf coh pth dk	M3	0 1 2 3 4
4 x 8	a ca sc asc fco/skf coh pth dk	M4	0 1 2 3 4
6 x 7	a ca sc asc fco/skf coh pth dk	M6	0 1 2 3 4
4 x 4	a ca sc asc fco/skf coh pth dk	MD	0 1 2 3 4
7 x 8	a ca sc asc fco/skf coh pth dk	MHN/M7	0 1 2 3 4
8 x 5	a ca sc asc fco/skf coh pth dk	MHN/M8	0 1 2 3 4
9 x 6	a ca sc asc fco/skf coh pth dk	MHN/M9	0 1 2 3 4
Codes: a- automatic sc- self corrected asc- attempted self-correction ca – counted all on fingers skf – skip counted on fingers coh- counted on in head pth – prolonged thinking time dk – didn't know		Codes: M0 – multiplying by 0 M1 – multiplying by 1 M10 – multiplying by 10 M5 – multiplying by 5 M2– multiplying by 2 M3 – multiplying by 3 M4 - multiplying by 4 M6 – multiplying by 6 M7– multiplying by 6 M8– multiplying by 6 M9– multiplying by 6 MD – multiplying doubles MHN- multiplying higher numbers	Codes: 0 – doesn't know 1 – counting strategies by ones or skip counting using fingers or drawings 2 - mental math/solving in head (usually skip counting) 3- using known facts and strategies 4- automatic recall
Comments:			

Part 2:
Multiplication Flexibility Assessment

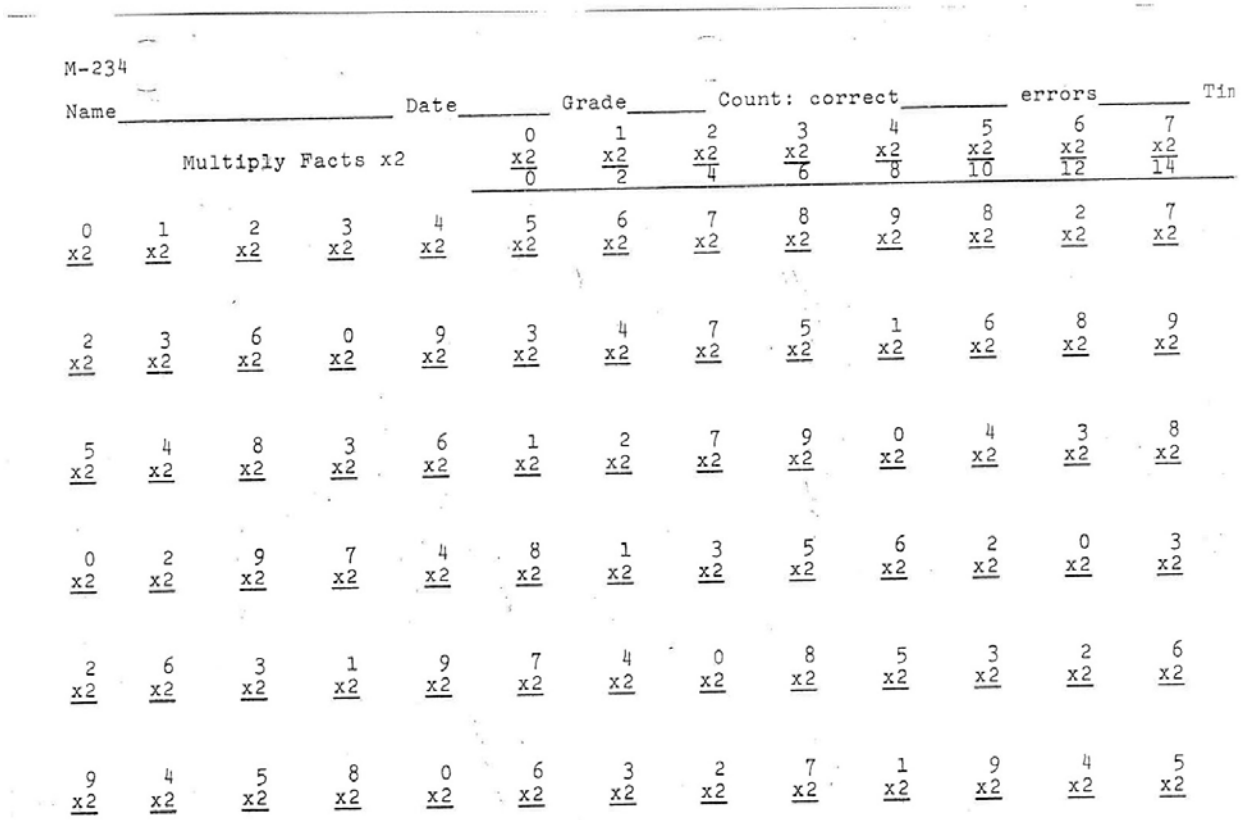
Teacher: We are now going to administer Part II of the Running Record. In this part of the Running Record we are going to talk about what strategies you use when you are solving basic multiplication facts. I am going to tell you a problem and then ask you to tell me how you think about it. I am also going to ask you about some different types of facts. Take your time as you answer and tell me what you are thinking as you see and do the math. I am going to take notes so I can remember everything that happened during this Running Record.

Multiplying by 0 What do you do when you are multiplying by zero? *For example:* 1 x 0 5 x 0 **M0**	**Multiplying by 1** What do you do when you are multiplying by 1? *For example:* 3 x 1 12 x 1 **M1**	**Multiplying by 10** What do you do when you are multiplying by 10? *For example:* 8 x 10 10 x 10 **M10**	**Multiplying by 5** What do you do when you are multiplying by 5? *For example:* 7 x 5 4 x 5 **M5**
Multiplying by 2 What do you do when you are multiplying by 2? *For example:* 2 x 4 2 x 9 **M2**	**Multiplying by 4** What do you think and do when you are multiplying by 4? *For example:* 4 x 2 4 x 9 **M4**	**Multiplying by 8** If I didn't know 8 x 3 what is a way that I could solve this problem? How about 8 x 9? **M8/MHN**	**Multiplying by 3** What strategies do you use when you are multiplying by 3? *For example:* 3 x 3 3 x 6 **M3**
Multiplying by 6 What do you think and do when you are multiplying a number by 6? *For example:* 6 x 5 6 x 9 **M6/MHN**	**Multiplying by 9** If I didn't know 9 x 4, what is a way I could think about and solve this problem? **M9/MHN**	**Multiplying by 7** If I were stuck on 7 x 9, what would you tell me to do? *How about:* 7 x 2 or 7 x 3? **M7/MHN**	**Multiplying by doubles** What do you do think and do when you are multiplying a number by itself? *For example:* 5 x 5 8 x 8 **MD**

Comments/Notes about gestures, behaviors, remarks:	**Question Prompts:** That's interesting/fascinating: tell me what you did. That's interesting/fascinating: tell me how you solved it. That's interesting/fascinating: tell me what you were thinking. How did you solve this problem? Can you tell me more about how you solve these types of problems? What do you mean when you say _____? (i.e. ten friends/neighbor numbers etc.)

Appendix C

Example of Rote Memorization worksheet for students to use when practicing their math facts.



M-234

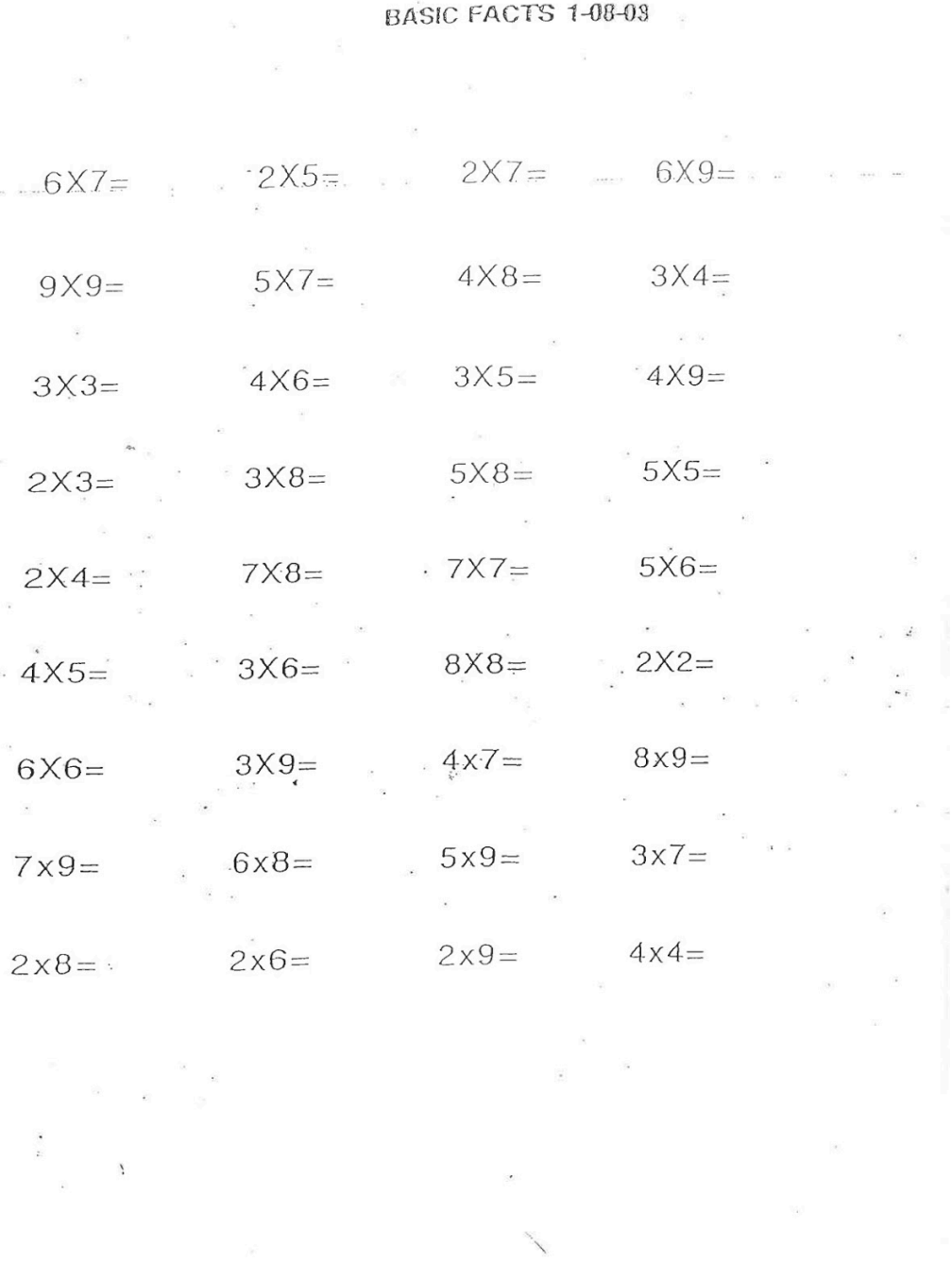
Name_____ Date_____ Grade_____ Count: correct_____ errors_____ Tin

Multiply Facts x2

					0 x2 0	1 x2 2	2 x2 4	3 x2 6	4 x2 8	5 x2 10	6 x2 12	7 x2 14
0 x2	1 x2	2 x2	3 x2	4 x2	5 x2	6 x2	7 x2	8 x2	9 x2	8 x2	2 x2	7 x2
2 x2	3 x2	6 x2	0 x2	9 x2	3 x2	4 x2	7 x2	5 x2	1 x2	6 x2	8 x2	9 x2
5 x2	4 x2	8 x2	3 x2	6 x2	1 x2	2 x2	7 x2	9 x2	0 x2	4 x2	3 x2	8 x2
0 x2	2 x2	9 x2	7 x2	4 x2	8 x2	1 x2	3 x2	5 x2	6 x2	2 x2	0 x2	3 x2
2 x2	6 x2	3 x2	1 x2	9 x2	7 x2	4 x2	0 x2	8 x2	5 x2	3 x2	2 x2	6 x2
9 x2	4 x2	5 x2	8 x2	0 x2	6 x2	3 x2	2 x2	7 x2	1 x2	9 x2	4 x2	5 x2

Appendix D

Example of untimed multiplication facts quiz



BASIC FACTS 1-08-03

6X7=	2X5=	2X7=	6X9=
9X9=	5X7=	4X8=	3X4=
3X3=	4X6=	3X5=	4X9=
2X3=	3X8=	5X8=	5X5=
2X4=	7X8=	7X7=	5X6=
4X5=	3X6=	8X8=	2X2=
6X6=	3X9=	4x7=	8x9=
7x9=	6x8=	5x9=	3x7=
2x8=	2x6=	2x9=	4x4=

Appendix E

Student Consent Form

Hello,

My name is Mrs. Nugent, and I am a student at the University of Maine at Farmington. I am interested in learning about how students learn their multiplication facts so I came up with a project/study where I will teach students their multiplication facts in different ways to see if one way works better than another way.

If you agree to be in my study/project, I am going to meet with you in a small group during your math class for 10 minutes each day to work on learning your multiplication facts.

You can ask questions about this study/project at any time. If you decide at any time not to finish, you can tell me you want to stop. This does not count for a grade in class, but your teacher will see how many multiplication facts you have learned during the time I have been working with you. When I present my project/study, I will not tell anyone's name so no one will know how you did.

If you sign this paper, it means that you have read/listened to this and that you want to be a part of my project/study. If you don't want to be in the project/study, don't sign this paper. Being in the project/study is up to you, and no one will be upset if you don't sign this paper or if you change your mind later.

Contact Information: If you have any questions about this study, please contact me, Julie Nugent, at julienugent@rsu57.org, 207-247-6126. You may also reach the faculty advisor, Brian Cavanaugh on this study at brian.cavanaugh@maine.edu or 1-207-778-7385.

You may also contact the Chair of the IRB Karol Maybury at karol.maybury@maine.edu

Your signature: _____ Date _____

Your printed name: _____ Date _____

Signature of person obtaining consent: _____ Date _____

Printed name of person obtaining consent: _____ Date _____

Appendix F

Parental Consent Form

12-9-19

Dear Parents,

I, Julie Nugent, am inviting your child to participate in a research project. I am currently a math specialist at Waterboro Elementary School, and I am also a student at the University of Maine at Farmington. I am researching how students best learn their multiplication facts.

What Will Your Child Be Asked to Do?
If you consent for your child to participate, your child will

- Be given a multiple intelligence survey to see what their multiple intelligence strength is. (Everyone has one)
- Be taught their multiplication facts in a small group for 10 minutes per day as part of their math class for 6 weeks.
- Students will be grouped according to their multiple intelligence strength. Students will then be taught their multiplication facts in ways that utilizes their multiple intelligence strength or by a rote multiplication method.
- Be monitored during that 6-week period to see how many multiplication facts they have learned.

Risks
There is the slight possibility that your child may not like the other students they have been grouped with.
Your child may find they don't like being pulled out of class to be working in a small group

Benefits: Your child may learn more about what their multiple intelligence strength is and how they can use that strength to help themselves when learning new material. They may learn many of their multiplication facts which is a 3rd grade standard for our school and which will benefit them as they continue to have to solve more complex math problems. Additionally, this study may help future students at school and in other classrooms, as I hope to learn more about how students best learn their multiplication facts and share that information with other teachers.

Confidentiality: I will be assigning each child a number and information will be recorded only with that number attached to it. No data will be collected using your child's name. The list of what child goes with what number will be kept confidential on a password protected computer. Your child's name will not be on any of the notes or documents. Data and any paperwork will be kept in in a locked file cabinet. Your child's name or other identifying information will not be
reported in any publications. I will review this information with your child's classroom teacher. She will know which student is which number so she can use this information in her classroom instruction. This information will be shared as my capstone project at the University of Maine at Farmington without any names attached to it. The information from this study will be destroyed at the end of the 2019/2020 school year.

Voluntary: Participation is voluntary. If you choose to have your child take part in this study, s/he may stop at any time. Whether or not your child participates will not impact your child's relationship with the school, his classroom teacher or any other teachers. Your child may skip any questions he does not wish to answer or withdraw from the research project at any time.

Contact Information: If you have any questions about this study, please contact me, Julie Nugent, at julienugent@rsu57.org or 207-247-6126. You may also reach the faculty advisor, Brian Cavanaugh on this study at brian.cavanaugh@maine.edu or 1-207-778-7385. You may also contact the Chair of the IRB, Karol Maybury at karol.maybury@maine.edu

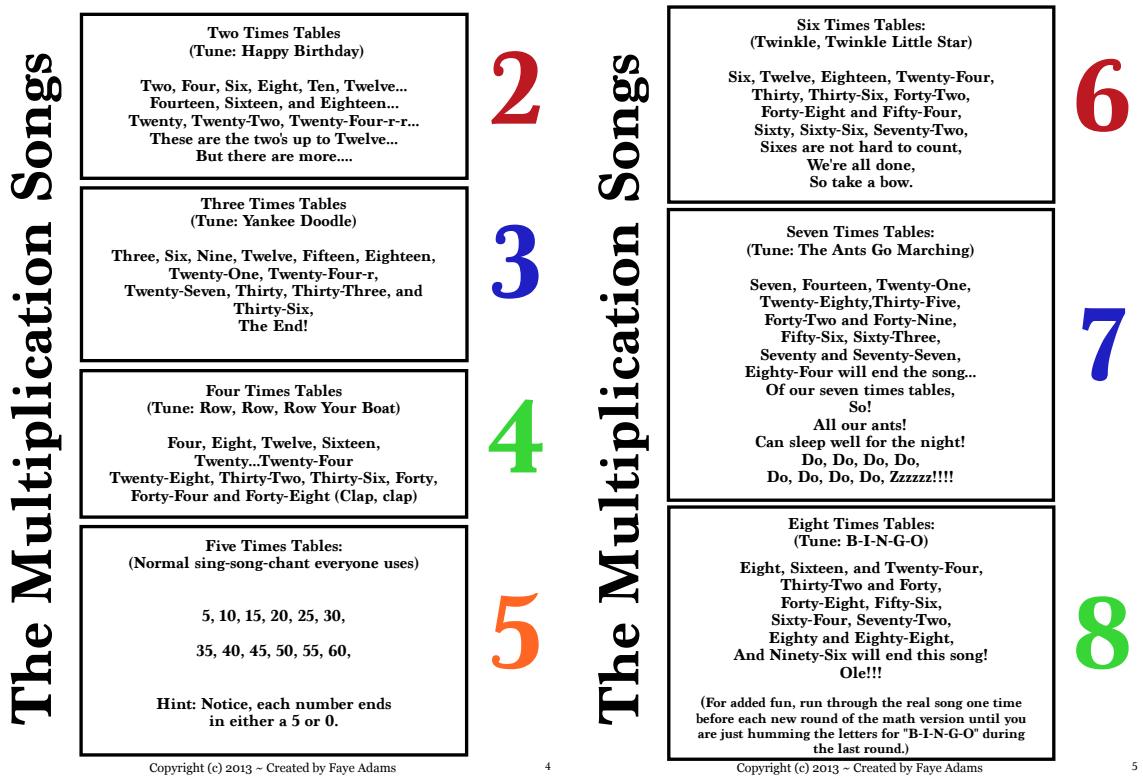
Your signature below indicates that you have read and give consent for your child to participate in this project. You will receive a copy of this form.

_____
Please print your child's name

_____ _____
Signature Date

Appendix G

Multiplication Songs



Appendix H

Multiplication Fact Box