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A Comparison of Two Approaches To Promote Multiplication Fact Fluency In Fifth Grade

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A Quantitative Research Methods Proposal

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Abstract

Fifth grade students are expected to be fluent in basic multiplication facts by the start of fifth grade, however many are not (Minnesota Department of Education, 2007). When fifth grade students are not fluent in basic multiplication facts, they struggle to understand and master grade level skills and standards (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; The Math Learning Center, 2017; Wong & Evans, 2007). This quantitative research study compared two classwide approaches to promote multiplication fact fluency in fifth grade. Throughout the research phase, one fifth grade math class practiced multiplication facts for ten minutes each day using computer-based multiplication fact practice and a second fifth grade math class practiced multiplication facts for ten minutes each day using game-based multiplication fact practice. A multiplication probe was given as a pretest before the research phase to determine the average digits correct for each fifth grade math class. Following the research phase, the same multiplication probe used as a pretest was administered for a second time as a posttest to determine the average digits correct for each fifth grade math class. The average increase in the digits correct from the pretest to the posttest for both classes was analyzed to determine which multiplication practice method is most effective in promoting multiplication fact fluency in fifth grade.

Chapter 1

Introduction

Introduction

This action research paper will examine two sections of fifth grade math in a district's fifth through eighth grade middle school building. In the state of Minnesota, students are expected to be fluent in basic multiplication facts by the end of fourth grade, but many fifth grade students are not fluent in basic multiplication facts (Minnesota Department of Education, 2007). When fifth grade students are not fluent in basic multiplication facts, they struggle to understand and master many skills and concepts taught in fifth grade math (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; The Math Learning Center, 2017; Wong & Evans, 2007). The school district in which this research study took place uses the math curriculum, *Bridges in Mathematics*, in grades kindergarten through fifth grade. Throughout the fifth grade curriculum, students are expected to solve multi-step equations, find common denominators and equivalent fractions, and use the standard algorithms for multiplication and division, all skills that require students to know basic multiplication facts (The Math Learning Center, 2017). Throughout her five years as a fifth grade math teacher, the researcher has always incorporated basic multiplication fact practice into her math classes each day. The researcher has observed that students have enjoyed practicing basic multiplication facts through game-based multiplication fact practice and computer-based multiplication fact practice the most. In this research study, the researcher sought to determine which method of multiplication fact practice was most effective in promoting basic multiplication fact fluency in her fifth grade math classroom.

Brief Literature Review

Research involving basic multiplication fact fluency supports what the researcher has noticed within her own fifth grade math classroom. When students are fluent in basic multiplication facts, they are able to learn and solve higher-level mathematical concepts and problems such as problems involving fractions with unlike denominators, multi-digit multiplication and division problems, multi-step equations, and problems that include algebra, all skills students are expected to learn and master within the researcher's fifth grade math classroom (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; The Math Learning Center, 2017; Wong & Evans, 2007). It has been noted that very few published math curriculums in the United States, including the math curriculum used in the researcher's school district, provide instruction and the necessary practice to promote multiplication fact fluency, leaving multiplication fact fluency practice up to individual teachers (Allen-Lyall, 2018; Berrett & Carter, 2018; Burns et al., 2015; Musti-Rao & Plati, 2015; Riccomini et al., 2017).

It has been shown that the use of computer-based multiplication practice and multiplication games are effective ways to practice and promote multiplication fact fluency when compared to other multiplication practice methods (Berrett & Carter, 2018; Kamii & Anderson, 2003; Kieger et. al, 2012; Kling & Bay-Williams, 2015; Musti-Rao & Plati, 2015; Ok & Bryant, 2016; Randel et. al, 1992). Benefits of computer-based multiplication practice include increased student engagement, motivation, increased time on task, and immediate feedback (Berrett & Carter, 2018; Duhon et al., 2019; Kromminga & Codding, 2021; Musti-Rao & Plati, 2015; Zhang et. al, 2015). Similarly, benefits of games to practice and promote multiplication fact fluency include opportunities for students to actively engage with multiplication strategies, increased student participation, motivation, and engagement, immediate feedback, opportunities to share

mathematical strategies and thinking, and a deepened number sense (Jackson et. al, 2013; Rutherford, 2015; Shaftel et al., 2005). For these reasons, the researcher chose to implement computer-based multiplication practice and multiplication games within her fifth grade math classes to compare their effectiveness in promoting multiplication fact fluency to determine which method was most effective in promoting multiplication fact fluency in fifth grade.

Statement of the Problem

Students in the state of Minnesota are expected to be fluent in basic multiplication facts by the end of fourth grade, but many fifth grade students are not fluent in basic multiplication facts (Minnesota Department of Education, 2007). The lack of basic multiplication fact fluency within the researcher's fifth grade math classroom has prevented many of her fifth grade students from being able to successfully solve grade level math problems and meet grade level math standards. Additionally, the math curriculum used in the researcher's school district does not provide instruction or the necessary practice to promote basic multiplication fact fluency (The Math Learning Center, 2017). These issues have left the researcher with the task of finding engaging ways for her students to practice basic multiplication facts to promote multiplication fact fluency in hopes that students will become fluent in basic multiplication facts, allowing them to successfully solve grade level math problems and meet grade level math standards.

Purpose of the Study

The purpose of this study was to determine whether game-based multiplication fact practice or computer-based multiplication fact practice was most effective in promoting multiplication fact fluency in fifth grade. The researcher sought to determine which method of multiplication fact practice was most effective in promoting multiplication fact fluency in fifth

grade in hopes of implementing the most effective basic multiplication fact practice method in the future.

Research Question

Is computer-based multiplication fact practice or game-based multiplication fact practice a more effective way to promote multiplication fact fluency in fifth grade?

Definition of Variables

Dependent Variables:

The dependent variable in this research study was multiplication fact fluency. Multiplication fact fluency is defined as the ability to quickly, efficiently, and accurately respond to basic multiplication fact problems (Burns et al., 2015; Hawkins et al., 2017; Kling & Bay-Williams, 2015; Musti-Rai & Plati, 2015; Stickney et al., 2012). Basic multiplication facts are defined as the multiplication of two one-digit numbers to get a product (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Both of the fifth grade math classes that participated in this study were assessed on multiplication fact fluency before and after the research phase, using a timed multiplication probe consisting of one-digit times one-digit multiplication problems.

Independent Variables:

The independent variables in this study were the method of multiplication fact practice. Each class that participated in the research study used a different method of multiplication fact practice. One fifth grade math class practiced basic multiplication facts using computer-based multiplication fact practice. The second fifth grade math class practiced basic multiplication facts

through game-based multiplication fact practice. Computer-based practice (independent variable A) is defined as a curriculum supplement for improving math skills, including math fact fluency (Hawkins et. al, 2017). Game-based practice (independent variable B) is defined as a challenge or task against an opponent that is governed by defined rules (Bright & Harvey, 1985).

Significance of the Study

This research study was significant because it compared the effectiveness of computer-based multiplication fact practice and game-based multiplication fact practice to promote multiplication fact fluency in fifth grade, something that had not been done before. The results of this research study provided the researcher insight into whether computer-based multiplication fact practice or game-based multiplication fact practice was most effective in promoting basic multiplication fact fluency in fifth grade. The findings of this study allowed the researcher to continue to implement the most effective method of basic multiplication fact practice in her classroom to promote multiplication fact fluency. This research study will also inform other practitioners in the field on whether computer-based multiplication fact practice or game-based multiplication fact practice is most effective in promoting basic multiplication fact fluency in fifth grade.

Research Ethics

Permission and IRB Approval

Prior to conducting this research study, the researcher sought MSUM's Institutional Review Board (IRB) approval to ensure the ethical conduct of research involving human subjects (Gay & Mills, 2019). Likewise, authorization to conduct this study was sought from the school district where the research study took place.

Informed Consent

The participants in this research study were protected. The participants of this research study were informed of the purpose of this research study using the Child Assent (See Appendix H). The researcher presented the purpose of this research study to participants visually and verbally prior to the start of the research study. The guardians of the participants in this research study were also informed of the purpose of this research study and the procedures of this research study by receiving a Consent Letter (See Appendix I). The guardians of the participants in their research study provided their written consent for their student to participate in this research study in the Consent Letter. Both participants and guardians were informed that this study was conducted as part of the researcher's Masters of Curriculum and Instruction Degree Program and that it would inform the researcher's teaching practice. Participants and guardians were also notified through written and/or verbal communication that they may withdraw from the study at any time without experiencing any negative consequences. Participant confidentiality was maintained through the use of assigning student numbers instead of names and by removing all identifying information.

Limitations

While several factors may influence whether or not a student becomes fluent in basic multiplication facts, this research study compared the effectiveness of two methods of basic multiplication fact practice to promote multiplication fact fluency. There were some limitations to this study. One limitation was that this study took place in two fifth grade math classes taught by the same teacher in northwest Minnesota. A second limitation of this study was the attendance of the individual students who participated in this research study. If students were absent frequently, their results may have impacted the findings of this study. Additionally, a student's

willingness to participate and engage in the practice methods of this study might have impacted the results of this study. Lastly, this study could not take into account any additional multiplication fact practice students did outside of this research study.

Conclusions

The lack of basic multiplication fact fluency within the researcher's math classroom prevented many fifth grade students from being able to successfully solve grade level math problems and meet grade level math standards (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; The Math Learning Center, 2017; Wong & Evans, 2007). This study focused on determining which method of basic multiplication fact practice was most effective in promoting basic multiplication fact fluency in fifth grade. This chapter introduced the research question, the research that had already been published on the topic of multiplication fact fluency before this research study took place, highlighted the problem the researcher will address, and the significance of this research study. The next chapter contains a review of existing literature regarding multiplication fact fluency, computer-based multiplication fact practice, and game-based multiplication fact practice, and will highlight the theoretical framework that supported this study.

Chapter 2

Literature Review

Introduction

Multiplication fact fluency is defined as the ability to quickly, efficiently, and accurately respond to multiplication fact problems (Burns et al., 2015; Hawkins et al., 2017; Kling & Bay-Williams, 2015; Musti-Rai & Plati, 2015; Stickney et al., 2012). Common Core State Standards for Mathematics highlight the need for students to know all products of two one-digit numbers by memory by the end of third grade (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Numerous studies have been conducted on the importance of multiplication fact fluency throughout math education; however, many students are not fluent in basic multiplication facts, hindering their ability to solve higher-level math problems (Burns et al., 2012; Burns et al., 2015; Hawkins, 2017; Letwinsky & Berry, 2017; Ok & Bryant, 2016; Wong & Evans, 2007). Throughout the researcher's five years as a fifth-grade math teacher, she experienced firsthand how important multiplication fact fluency is and just how many students lack multiplication fact fluency. It was critical for the researcher to explore multiplication fact fluency and ways to promote multiplication fact fluency in her own classroom. This literature review examined the existing research involving multiplication fact fluency and engaging ways for students to practice basic multiplication facts to promote multiplication fact fluency.

Multiplication Fact Fluency

Importance of Multiplication Fact Fluency

Multiplication fact fluency, the ability to quickly, efficiently, and accurately respond to multiplication fact problems, is a foundational skill for students to obtain (Burns et al., 2015; Hawkins et al., 2017; Kling & Bay-Williams, 2015; Musti-Rai & Plati, 2015; Stickney et al.,

2012). Multiplication fact fluency allows students to have the foundational skills necessary to learn and solve higher-level mathematical concepts and problems such as fractions, multi-digit multiplication, multi-digit division, multi-step problems, word problems, and algebra (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; Wong & Evans, 2007). Letwinsky and Berry (2017) highlighted research that has shown when students cannot retrieve basic multiplication facts from memory, they cannot produce correct answers to higher-level mathematical problems. Wong and Evans (2007) explained how the importance of multiplication fact fluency becomes noticeable when students are not fluent in basic multiplication facts. Wong and Evans continued to discuss how lessons stall when students cannot recall basic multiplication facts from memory or when basic multiplication facts need to be looked up. Not only is multiplication fact fluency a foundational skill for higher-level concepts, problems, and success in later grades, but multiplication fact fluency can also lead to significant outcomes in a student's life (Allen-Lyall, 2018; Hawkins et al., 2017). Significant outcomes can include things such as attending and graduating from college and broader options for employment when one is fluent and confident in their mathematical ability (Allen-Lyall, 2018; Hawkins et al., 2017).

Lack of Multiplication Fact Fluency Instruction and Practice

Research has shown the importance of multiplication fact fluency, but very few published math curriculums in the United States provide instruction and the necessary practice to promote multiplication fact fluency (Allen-Lyall, 2018; Berrett & Carter, 2018; Burns et al., 2015; Musti-Rao & Plati, 2015; Riccomini et al., 2017). Many elementary school teachers know the importance of multiplication fact fluency, but place little emphasis on basic multiplication fact instruction and practice. Many teachers also assume students have acquired basic multiplication fact instruction and fluency in previous grades (Burns et al., 2015). Allen-Lyall (2018) states,

"Because there is little help given in published mathematics programs (National Mathematics Advisory Panel, 2008), teachers continue to rely on methods that they themselves experienced, successfully, or unsuccessfully as young learners" (p. 392). Allen-Lynall also explained the difficulty teachers face in finding the time and sufficient methods to teach students basic multiplication facts (Allen-Lyall, 2018).

Cognitive Load and Working Memory

When students are not fluent in basic multiplication facts, they must exhaust their cognitive resources to calculate the basic multiplication fact before being able to solve a more complex problem, increasing their cognitive load and cognitive demand (Berrett & Carter, 2018). Similarly, when students lack the ability to retrieve basic multiplication facts from memory, they are likely to experience a high cognitive load and solve problems inaccurately (Baker & Cuevas, 2018; Letwinsky & Berry, 2017). Wong and Evans (2007), stated, "Without procedural fluency and the ability to recall facts from memory, the student's focus during problem-solving will be on basic skills rather than the task at hand, thus drawing attention away from the learning objectives of the task". Multiplication fact fluency allows students to commit basic multiplication facts to their long-term memory, ultimately freeing up their working memory, and allowing them to focus their attention on the more complex problem at hand (Allen & Lynall, 2018; Burns et al., 2012; Letwinsky & Berry, 2017; Wong & Evans, 2007).

Computer-Based Multiplication Fact Practice

Hawkins, Collins, Hernan, and Flowers (2017) defined computer-assisted instruction, or practice, as "a curriculum supplement for improving math skills, including math fact fluency". There are many benefits to using computer-assisted instruction, or computer-based practice to practice multiplication facts. Benefits of using computer-based practice to practice multiplication

facts include increased student engagement, increased motivation, increased time on task, immediate feedback, progress monitoring, individualized and adaptive instruction, high accessibility, and low demand on the teacher (Berrett & Carter, 2018; Duhon et al., 2019; Kromminga & Codding, 2021; Musti-Rao & Plati, 2015; Zhang et. al, 2015). Many studies have examined the effectiveness of computer-based multiplication fact practice in promoting multiplication fact fluency. The four studies below are just a few examples of studies that have found computer-based multiplication fact practice to be effective in promoting multiplication fact fluency (Berrett & Carter, 2018; Kieger et. al, 2012; Musti-Rao & Plati, 2015; Ok & Bryant, 2016).

Musti-Rao and Plati (2015) conducted a study to compare two classwide multiplication fact interventions. The two interventions used in the study were the Detect, Practice, and Repair (DPR) intervention and digital multiplication flashcards on the Math Drills iPad application (Musti-Rao & Plati, 2015). Participants in the study included twelve third-grade students in a general education classroom (Musti-Rao & Plati, 2015). In both intervention phases, students participated in the intervention for five minutes for eight sessions (Musti-Rao & Plati, 2015). Though both interventions showed to be effective in promoting multiplication fact fluency, students showed greater gains from the baseline to intervention during the digital multiplication flashcard intervention in comparison to the DPR intervention (Musti-Rao & Plati, 2015).

Ok and Bryant (2016), found that students identified as having learning disabilities improved and maintained multiplication fact fluency after participating in an iPad-based multiplication fact intervention. The study participants included four fifth-grade students identified as having a learning disability and who demonstrated low fluency in multiplication (Ok & Bryant, 2016). Throughout the intervention, students practiced one-digit times one-digit

multiplication facts on the iPad application, Math Evolve, for fifteen thirty-minute sessions over a three-week time (Ok & Bryant, 2016). The study found that students improved and maintained their multiplication fact fluency following the three-week intervention phase and two-week maintenance phase (Ok & Bryant, 2016).

The Imagine Math Facts game, Times Attack, was used in a study by Berrett and Carter (2018) to teach multiplication facts. The study involved sixty-three third-grade students, eleven who were below proficient in third-grade mathematics, twenty-one who were partially proficient in third-grade mathematics, fifteen who were proficient in third-grade mathematics, and sixteen whose math performance exceeded proficiency in third-grade mathematics (Berrett & Carter, 2018). Throughout the ten-week study, all students played the game, Timez Attack, to practice one-digit times one-digit multiplication problems two times a week for twenty to thirty minutes (Berrett & Carter, 2018). The one-minute assessment probe consisting of thirty one-digit times one-digit multiplication problems used as a pretest, intervention progressing monitoring tool, and maintenance phase assessment, showed that all sixty-three participants demonstrated improved and maintained multiplication fact fluency (Berrett & Carter, 2018).

Kiger, Herro, and Prunty (2012) implemented a nine-week study in a Midwestern elementary school involving two third-grade classrooms. One class consisted of forty-one students who practiced multiplication facts using an iPod touch (Kieger et. al, 2012). The second class consisted of forty-six students who practiced multiplication using traditional flashcards, multiplication games, and fact triangles (Kieger et. al, 2012). Each classroom practiced multiplication facts for ten minutes each day throughout a nine-week period (Kieger et. al, 2012). On a post-intervention multiplication test, the class of students who practiced multiplication facts using an iPod touch outperformed the class of students who used more traditional methods of

multiplication fact practice, by answering more multiplication problems correctly (Kieger et. al, 2012).

Game-Based Multiplication Fact Practice

The word game as defined by Bright and Harvey (1985), is a challenge or task against an opponent that is governed by defined rules. Research has noted numerous benefits of playing mathematical games. Benefits include opportunities for students to actively engage with what they are learning, opportunities for students to practice skills, increased student participation, increased student motivation, immediate feedback, opportunities for strategic mathematical thinking, deepened number sense, and promotion of fluency (Jackson et. al, 2013; Rutherford, 2015; Shaftel et al., 2005). Godfrey and Stone (2013) also found that playing math fact fluency games allows students to focus on higher-level thinking and strategies. They also found that through discussing their thinking and strategies with a partner, students' fact fluency increased (Godfrey & Stone, 2013).

With further evidence to support multiplication fact practice, internationally recognized professors of mathematics, Kling and Bay-Williams stated, "...meaningful practice involves helping students learn their facts through rich, engaging, mathematical activities that provide the additional benefits of promoting problem-solving, reasoning, and communicating mathematical thinking" (Kling & Bay-Williams, 2015, p.555). Kling and Bay-Williams highlighted multiplication fact games as a meaningful way to practice multiplication facts by stating, "Multiplication facts games provide meaningful (and enjoyable) practice" (Kling & Bay-Williams, 2015, p.555).

Likely due to the increased use of technology used in schools today and the amount of research that has been done involving computer-assisted instruction and computer-based

practice, very little research has been done in the last twenty years on the effectiveness of games in promoting mathematical skills. Though not conducted recently, a few studies have indicated the effectiveness of using games in the elementary classroom to promote practice, retention, and fluency.

In researching the effectiveness of games for educational purposes, Randel, Morris, Wetzel, and Whitehill (1992), found games to be more effective than traditional instructional approaches and that students showed more interest in games than what is considered traditional classroom instruction. Their study also found that playing educational games results in increased content retention (Randel, Morris, Wetzel, & Whitehill, 1992).

Teachers Kamii and Anderson (2003) applied this theory throughout the year with their students. They had their third-grade students practice multiplication facts through the playing of math games instead of traditional worksheets and timed tests. At the end of the school year, Kamii and Anderson gave their students a summative assessment consisting of one hundred multiplication problems (Kamii & Anderson, 2003). All but one student, who made two errors, scored one hundred percent on the multiplication assessment, showing the effectiveness of practicing multiplication facts through the playing of games (Kamii & Anderson, 2003).

Theoretical Framework

Both computer-based multiplication fact practice and game-based multiplication fact practice, are supported by John Dewey's Social Learning theory. Computer-Based multiplication fact practice and game-based multiplication fact practice allow students to be engaged in what they are doing and allow students to practice basic multiplication facts through hands-on experiences. Through the playing of multiplication games, students interact with other learners and use their hands to play the games. In computer-based multiplication practice, students use

their hands to enter the multiplication answer through the use of the computer keyboard or the touchscreen on the computer. Dewey believed that education should be socially engaging and that learning should take place through developmentally appropriate experiences (Dewey, 1938). Dewey also believed that the classroom activities planned by teachers should be driven by the interest and engagement of students (Flinders & Thornton, 2013). In both computer-based multiplication practice and game-based multiplication practice within this research study, students were engaged in the multiplication fact practice. While playing a multiplication game, students were motivated to win, through computer-based multiplication practice, students were motivated to improve the number of facts they solved accurately.

Research Question

Is computer-based multiplication fact practice or game-based multiplication fact practice a more effective way to promote multiplication fact fluency in fifth grade?

Conclusions

This chapter reviewed the literature that supported this research study in determining if computer-based multiplication fact practice or game-based multiplication fact practice is a more effective way to promote multiplication fact fluency in fifth grade. The research presented within this literature review showed just how important multiplication fact fluency is and the effectiveness of both computer-based multiplication fact practice and game-based multiplication fact practice. The information presented within this literature review along with the data collected throughout the research phase allowed the researcher to determine if computer-based multiplication fact practice or game-based multiplication fact practice is a more effective way to promote multiplication fact fluency in fifth grade. The next chapter will explain and highlight

how data was collected and analyzed to determine which method of basic multiplication fact fluency is most effective in promoting multiplication fact fluency in fifth grade.

Chapter 3

Methods

Introduction

While there is strong evidence to support computer-based multiplication fact practice and game-based multiplication fact practice in comparison to other methods of multiplication fact practice to promote multiplication fact fluency, research comparing the effectiveness between the two is something that had not been done before this research study. Research comparing the effectiveness between computer-based multiplication fact practice and game-based multiplication practice to promote multiplication fact fluency was needed and this research study is the first of its kind. This research study contributed to the existing research on methods of multiplication fact practice to promote multiplication fact fluency and filled the void by comparing computer-based multiplication fact practice and game-based multiplication fact practice to promote multiplication fact fluency. This chapter explains how this research study was conducted to compare the effectiveness of computer-based multiplication fact practice and game-based multiplication fact practice to promote multiplication fact fluency in fifth grade.

Research Question

Is computer-based multiplication fact practice or game-based multiplication fact practice a more effective way to promote multiplication fact fluency in fifth grade?

Research Design

This study was a quantitative research study in which quantitative data was collected and analyzed to determine the most effective method of multiplication fact practice to promote multiplication fact fluency in fifth grade. This research study used a pretest multiplication probe

(see Appendix A) to determine the average digits correct for both of the fifth grade math classes that participated in this research study before the research phase began. Throughout the research phase, one fifth grade math class practiced multiplication facts for ten minutes each day through the use of computer-based multiplication fact practice. The second fifth grade math class that participated in this study practiced multiplication facts for ten minutes each day through the use of game-based multiplication fact practice. Following the research phase, the same multiplication probe used as the pretest was administered a second time as a posttest to determine the correct average digits for each fifth grade math class. The increase in the digits correct from the pretest to the posttest for both classes was analyzed to determine which multiplication practice method is most effective in promoting multiplication fact fluency in fifth grade. A quantitative research study comparing quantitative data between two methods of multiplication fact practice between two different fifth grade math classes was chosen because the learning model of the research setting lent itself to work well when comparing two different groups. Two different methods of multiplication fact practice were chosen to allow for both groups to practice multiplication facts to promote multiplication fact fluency throughout the research phase.

Setting

The setting of this study was a 5th-8th grade middle school in Minnesota. The town in which this research study took place has a population of approximately 45,000 people and is best known for agriculture and the local higher education institutions. The school in which this research study took place had approximately 2,150 students enrolled in grades 5-8. Of the 2,150 students enrolled in the 5th-8th grade middle school, 69.8% were White, 9.9% were Black or African American, 9.3% were Hispanic/Latino, 3% were American Indian or Alaska Native, 1.1% were Asian or Asian/Pacific Islander, and 6.8% were two or more races. Of the students

enrolled in the 5th-8th grade middle school, 42% of students scored at or above the proficient level for math throughout the 2021-22 school year, and 55% of students scored at or above the proficient level for reading throughout the 2021-22 school year. 35.52% of the students enrolled in the 5th-8th grade middle school received free and reduced lunch and 17.4% of students received special education services.

Participants

The participants in this research study included 46 students enrolled in two fifth grade math classes. All students were in fifth grade throughout the 2022-23 school year and ranged between ten and eleven years old. Of the 46 students, 20 (43.5%) were males and 26 (56.5%) were females. Of the 46 participants, 67.4% were White, 8.6% were Black or African American, 8.6% were Hispanic, 8.6% were American Indian or Alaska Native, 2.2% were Asian or Asian/Pacific Islander, and 4.3% were Nonwhite. Two students (4.3%) were on 504 plans and one student (2.1%) was on an IEP.

Sampling

This research study involved 46 students in two fifth grade math classes. The students were a purposive sample because the students were assigned to the class rosters. One fifth grade math class was composed of 23 students who practiced multiplication facts using computer-based multiplication practice. A second fifth grade math class composed of 23 students practiced multiplication facts using game-based multiplication practice. The two groups of students practiced multiplication facts in two different groups using two different multiplication practice methods. A multiplication probe was used as a pretest before the research phase and again as a posttest after the research phase to determine the increase in the average of digits

correct from the pretest to the posttest for both classes to determine which multiplication fact practice method is most effective in promoting multiplication fact fluency in fifth grade.

Instrumentation

The instrumentation that was used to collect data for this research study was a timed multiplication probe consisting of all the 1-9 multiplication facts. The multiplication probe (See Appendix A) consisted of 45 multiplication problems and students had 3 minutes to complete the probe. The multiplication probe was administered to all participants as a pretest before the research phase and as a posttest following the research phase.

Data Collection.

Pretest data was collected for all participants before the research phase using a 1-9 multiplication fact probe. The 1-9 multiplication fact probe was also used as a posttest following the research phase. The researcher administered the pretest and posttest to all participants of the research study.

Data Analysis.

After data was collected, the researcher scored each pretest and posttest out of 45 points to determine the number of digits correct.

Procedures

This research study took place over an eight-week period. On the first day of the study, both fifth grade math classes that participated in the research study completed the pretest consisting of all of the 1-9 multiplication fact problems. Students had 3 minutes to complete the

45-question multiplication probe. After the completion of the pretest, both fifth grade math classes started practicing basic multiplication facts for ten minutes each day for eight weeks.

Throughout the research phase, one class practiced basic multiplication facts for ten minutes each day using computer-based multiplication fact practice. Participants used the *Quick Flash II* (See Appendix B) option on multiplication.com The second class practiced basic multiplication facts for ten minutes each day using game-based multiplication fact practice. Participants practicing multiplication facts through games played the games *On The Double* (See Appendix C)*, Triple It* (See Appendix D)*, Quadruple It* (See Appendix E)*, Trios* (See Appendix F)*,* and *Fixed Factor War* (See Appendix G) from the book, *Math Fact Fluency 60+ Games and Assessment Tools to Support Learning and Retention*, by Jennifer Bay-Williams and Gina Kling.

Throughout the first week of the research phase, students practiced facts 1x2, 2x2, 3x2, 4x2, 5x2, 6x2, 7x2, 8x2, and 9x2. Throughout the second week of the research phase, students practiced facts 1x3, 2x3, 3x3, 4x3, 5x3, 6x3, 7x3, 8x3, and 9x3. Throughout the third week of the research phase, students practiced facts 1x4, 2x4, 3x4, 4x4, 5x4, 6x4, 7x4, 8x4, and 9x4. Throughout the fourth week of the research phase, students practiced facts 1x5, 2x5, 3x5, 4x5, 5x5, 6x5, 7x5, 8x5, and 9x5. Throughout the fifth week of the research phase, students practiced facts 1x6, 2x6, 3x6, 4x6, 5x6, 6x6, 7x6, 8x6, and 9x6. Throughout the sixth week of the research phase, students practiced facts 1x7, 2x7, 3x7, 4x7, 5x7, 6x7, 7x7, 8x7, and 9x7. Throughout the seventh week of the research phase, students practiced facts 1x8, 2x8, 3x8, 4x8, 5x8, 6x8, 7x8, 8x8, and 9x8. Throughout the eighth week of the research phase, students practiced facts 1x9, 2x9, 3x9, 4x9, 5x9, 6x9, 7x9, 8x9, and 9x9.

On the last day of the research study, both fifth grade math classes that participated in the research study completed the posttest consisting of all of the 1-9 multiplication fact problems. Students had 3 minutes to complete the 45-question multiplication probe.

Ethical Considerations

The well-being of the participants of this research study was of the utmost importance to the researcher. Before the start of the research study, informed consent from the guardians of the participants was collected. Throughout the research study, the identities of the participants were not shared with anyone and all individual information was recorded and tracked under an identification number and not the participants' names.

Conclusions

This chapter explained the design of this research study, the setting where the research study took place, the participants of the research study, and how the data was collected, interpreted, and analyzed to determine which method of multiplication fact practice is most effective in promoting multiplication fact fluency in fifth grade. In the next chapter, the results of this research study will be presented.

Chapter 4

Results

Introduction

In the state of Minnesota, students are expected to be fluent in basic multiplication facts by the end of fourth grade, but many fifth grade students are not fluent in basic multiplication facts (Minnesota Department of Education, 2007). When fifth grade students are not fluent in basic multiplication facts, they struggle to understand and master many skills and concepts taught in fifth grade math (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; The Math Learning Center, 2017; Wong & Evans, 2007). Therefore, this study aimed to provide fifth grade students the opportunity to practice basic multiplication facts while also answering the research question, *Is computer-based multiplication fact practice or game-based multiplication fact practice a more effective way to promote multiplication fact fluency in fifth grade?*

Throughout the eight week research phase, one fifth grade math class practiced multiplication facts for ten minutes each day using computer-based multiplication fact practice and a second fifth grade math class practiced multiplication facts for ten minutes each day using game-based multiplication fact practice. A multiplication probe was given as a pretest before the research phase to determine the average digits correct per minute for each fifth grade math class. Following the research phase, the same multiplication probe used as a pretest was administered for a second time as a posttest to determine the average digits correct for each fifth grade math class. The average increase in the digits correct from the pretest to the posttest for both classes was analyzed to determine which multiplication practice method is most effective in promoting multiplication fact fluency in fifth grade.

Data Collection

As a quantitative research study, the purpose of this study was to determine if computer-based multiplication fact practice or game-based multiplication fact practice is a more effective way to promote multiplication fact fluency in fifth grade by comparing the average growth from the pretest to the posttest for each class that participated in the research study. A 3 minute multiplication probe consisting of all 1-9 multiplication facts was given as a pretest before the research phase to determine the average digits correct for each fifth grade math class. Following the research phase, the same multiplication probe that was used as a pretest was administered for a second time as a posttest to determine the average digits correct for each fifth grade math class. Prior to the start of the research phase, it was determined that the class with the greatest average growth from the pretest to the posttest would determine the method of multiplication fact practice that is most effective in promoting multiplication fact fluency in fifth grade.

Results

As shown in Table 1, both of the classes that participated in the research study experienced growth between their average pretest scores and their average posttests scores.

Table 1

Multiplication Fact Practice Data

Computer-Based Multiplication Practice	Average Pre-Test Score out of 45 Points	Average Pre-Test Score out of 45 Points	Average Growth Out of 45 Points
	28 (62%)	36 (80%)	9 (20%)
Game Multiplication Practice	25 (56%)	35 (78%)	11 (24%)

Note. This data was collected in the classroom.

*p = .218, two-tailed. $^{+}$p = .109 one-tailed.

Data Analysis

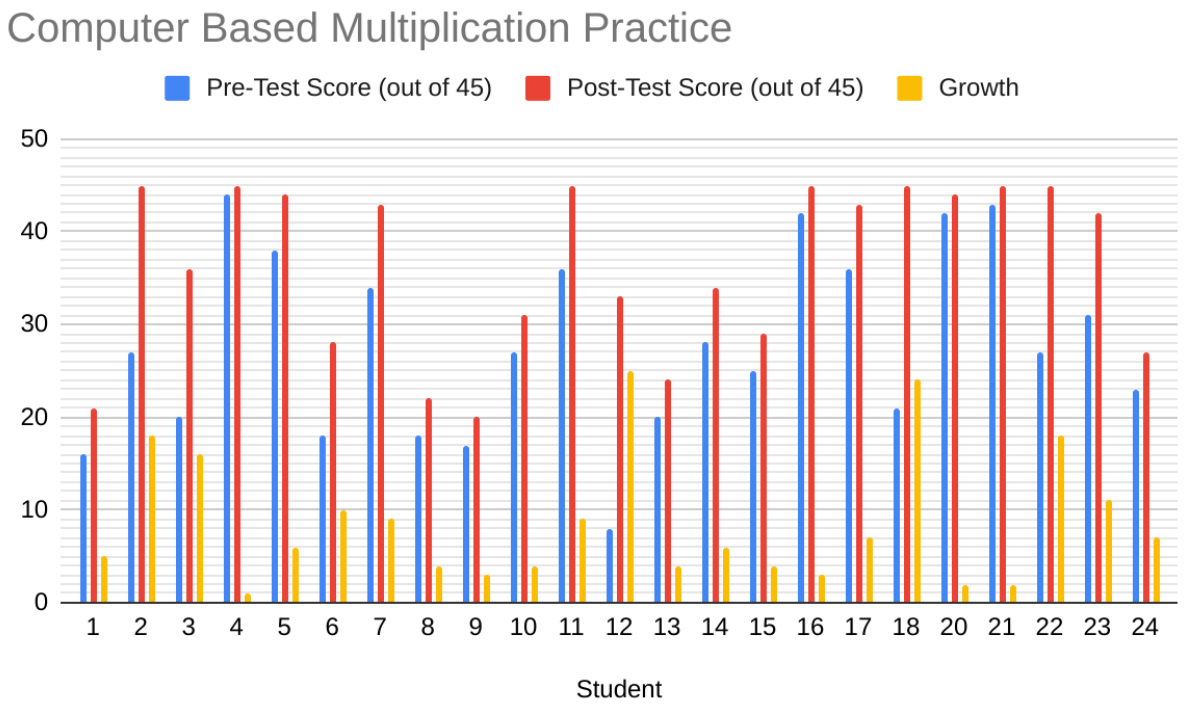
Computer-Based Multiplication Fact Practice

Before participating in ten minutes of computer-based multiplication fact practice each day throughout the eight week research phase, the average pretest score for the class that practiced multiplication facts through computer-based practice was 28 out of 45 points, or 62%. The average posttest score for the class that practiced multiplication facts through computer-based practice was 36 out of 45 points, or 80%. The class that practiced multiplication facts through computer-based practice had an average growth from pretest to posttest of 9 points, or 20%. As shown in Figure 4.1, all students that participated in the computer-based multiplication fact practice experienced growth from their pretest score at the beginning of the research phase to their posttest score at the end of the research phase, showing computer-based

multiplication fact practice to be an effective way to promote multiplication fact fluency in fifth grade.

Figure 4.1

Computer Based Multiplication Practice Data



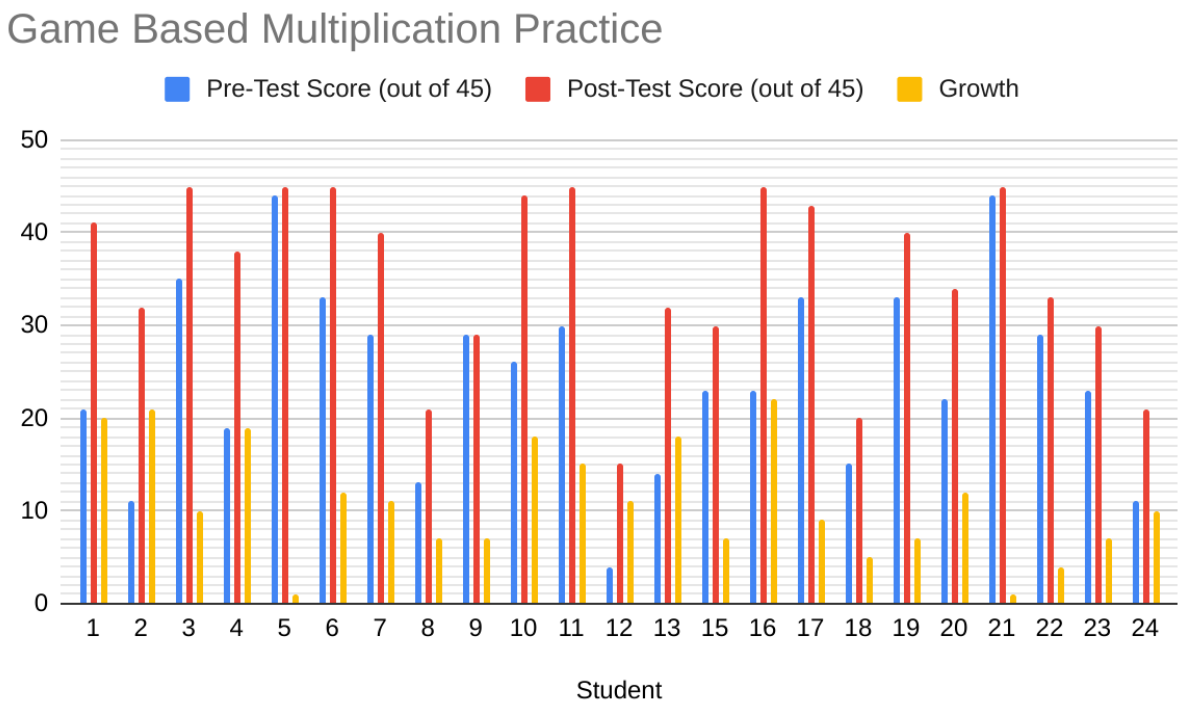
Game-Based Multiplication Fact Practice

Before participating in ten minutes of game-based multiplication practice each day throughout the eight week research phase, the average pretest score for the class that practiced multiplication facts through game-based practice was 25 out of 45 points, or 56%. The average posttest score for the class that practiced multiplication facts through game-based practice was 35 out of 45 points, or 78%. The class that practiced multiplication facts through game-based practice had an average growth from pretest to posttest of 11 points, or 24%. As shown in Figure 4.2, all students that participated in the game-based multiplication fact practice experienced

growth from their pretest score at the beginning of the research phase to their posttest score at the end of the research phase, showing game-based multiplication fact practice to be an effective way to promote multiplication fact fluency in fifth grade.

Figure 4.2

Game Based Multiplication Practice Data



Conclusion

Throughout this research study, the researcher was determined to answer the research question, *is computer-based multiplication fact practice or game-based multiplication fact practice a more effective way to promote multiplication fact fluency in fifth grade?* Throughout the duration of the research phase the researcher planned on answering the research question by determining the average growth from the pretest to the posttest for each class and concluding that the class with the greatest average growth from the pretest to the posttest would determine the

method of multiplication fact practice that is most effective in promoting multiplication fact fluency in fifth grade. However, because the average growth from the pretest to the posttest was so similar between the two classes that participated in the research study, a T-Test was used to calculate the *P*-Value to determine if the average growth between the two classes showed a statistically significant difference. With a $P = .109$, there was no statistically significant difference between the average growth of the two groups. The findings of this research study indicate that computer-based multiplication fact practice and game-based multiplication fact practice are both effective in promoting multiplication fact fluency in fifth grade and that neither is more effective than the other.

Chapter 5

Implications For Practice

Action Plan

The purpose of this research study was to answer the research question, *is computer-based multiplication fact practice or game-based multiplication fact practice a more effective way to promote multiplication fact fluency in fifth grade?*, to allow for the researcher to to implement the most effective method of multiplication fact practice in their fifth grade classroom to promote multiplication fact fluency. The findings of this research study have allowed the researcher to conclude that both computer-based multiplication fact practice and game-based multiplication fact practice are effective in promoting multiplication fact fluency and that neither method is more effective than the other.

The findings of this study will allow for the research to confidently implement both computer-based multiplication fact practice and game-based multiplication fact practice to promote multiplication fact fluency in fifth grade. The researcher will continue to implement computer-based multiplication practice in fifth grade math classes where students are engaged and more successful when working independently. The researcher will continue to implement game-based multiplication practice in fifth grade math classes where students are engaged and more successful when actively interacting with others.

Plan for Sharing

As one of many fifth grade math teachers in their district, the researcher will share the findings of this research study with their grade level content area colleagues during a Professional Learning Community meeting. The researcher will share their research and results

and encourage other fifth grade math teachers to implement daily multiplication fact practice in their math classes through computer-based multiplication fact practice, game-based multiplication fact practice, or a combination of both to promote multiplication fact fluency in fifth grade. It is the hope of the researcher that all fifth grade math teachers implement either computer-based multiplication fact practice or game-based multiplication fact practice to allow fifth grade students to be more successful with the skills and concepts taught in fifth grade math (Allen-Lyall, 2018; Burns et al., 2012; Ok & Bryant, 2016; The Math Learning Center, 2017; Wong & Evans, 2007).

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Appendix

Appendix A

Pretest and Posttest Multiplication Probe

Name _____ Date _____

3 × 9	3 × 4	2 × 2	8 × 8	2 × 3	2 × 6	6 × 6	8 × 4
5 × 4	2 × 8	9 × 9	5 × 5	7 × 2	1 × 1	5 × 2	3 × 3
6 × 1	3 × 1	5 × 6	4 × 9	9 × 8	9 × 6	3 × 6	1 × 4
2 × 9	4 × 4	4 × 2	7 × 3	3 × 8	7 × 7	9 × 5	7 × 5
8 × 1	9 × 7	1 × 2	5 × 1	4 × 7	6 × 8	1 × 9	5 × 8
5 × 3	4 × 6	7 × 8	6 × 7	7 × 1			

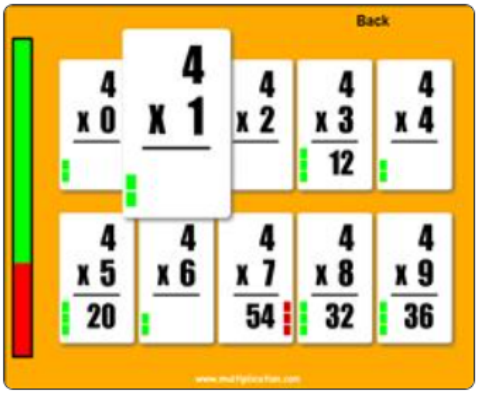
Appendix B

Quick Flash II Computer-Based Multiplication Fact Practice

Instructions

Step 1

After Quick Flash loads, you can select your starting fact family (Hit the back button to choose a different fact family).



Step 2

Here is Quick Flash in action! A flash card will pop up and you will enter the answer using the keypad. If you enter the correct answer, a green box will be stacked on the left side of the card. If you answered the problem incorrectly, a red box will be stacked on the right side of the card. Each flash card will pop up 3 times during each level. There is also a red timer progressing on the left side of the screen. If you don't answer the equation before the timer runs out, it is marked incorrect. However, if you answer the problem correctly after the timer runs out you will receive a yellow block (The timer is set to 6 seconds).

Appendix C

On The Double Game-Based Multiplication Fact Practice

GAME 26

ON THE DOUBLE

For two to four players, you need: 10-sided die or deck of playing cards with face cards removed (ace = 1), 15 counters per student, 1 On the Double game board for each student

2	4	6	8	10	12	14	16	18	20

How to play: Students place all their counters over different spaces on the game board. (For example, if they think an 8 will occur most often, they may place more counters above the 8. Once counters have been placed, they cannot be moved to a different location. Players take turns rolling the die, doubling the number, saying the corresponding multiplication fact aloud (e.g., "2 times 4 equals 8"), and removing a counter from that space on the board. If they do not have a counter on that number, no counter is removed. The first student to remove all their counters wins the game.

Possible variations: Use the game for other facts, naming it Triple It (for multiplying by 3) or Quadruple (for multiplying by 4). If using playing cards, include kings as wild cards.

2	4	6	8	10	12	14	16	18	20

2	4	6	8	10	12	14	16	18	20

Appendix D

***Triple It* Game-Based Multiplication Fact Practice**

GAME 26

ON THE DOUBLE

For two to four players, you need: 10-sided die or deck of playing cards with face cards removed (ace = 1), 15 counters per student, 1 On the Double game board for each student

2	4	6	8	10	12	14	16	18	20

How to play: Students place all their counters over different spaces on the game board. (For example, if they think an 8 will occur most often, they may place more counters above the 8. Once counters have been placed, they cannot be moved to a different location. Players take turns rolling the die, doubling the number, saying the corresponding multiplication fact aloud (e.g., "2 times 4 equals 8"), and removing a counter from that space on the board. If they do not have a counter on that number, no counter is removed. The first student to remove all their counters wins the game.

Possible variations: Use the game for other facts, naming it Triple It (for multiplying by 3) or Quadruple (for multiplying by 4). If using playing cards, include kings as wild cards.

3	6	9	12	15	18	21	24	27	30

3	6	9	12	15	18	21	24	27	30

Appendix E

Quadruple It Game-Based Multiplication Fact Practice

GAME 26

ON THE DOUBLE

For two to four players, you need: 10-sided die or deck of playing cards with face cards removed (ace = 1), 15 counters per student, 1 On the Double game board for each student

2	4	6	8	10	12	14	16	18	20

How to play: Students place all their counters over different spaces on the game board. (For example, if they think an 8 will occur most often, they may place more counters above the 8. Once counters have been placed, they cannot be moved to a different location. Players take turns rolling the die, doubling the number, saying the corresponding multiplication fact aloud (e.g., "2 times 4 equals 8"), and removing a counter from that space on the board. If they do not have a counter on that number, no counter is removed. The first student to remove all their counters wins the game.

Possible variations: Use the game for other facts, naming it Triple It (for multiplying by 3) or Quadruple (for multiplying by 4). If using playing cards, include kings as wild cards.

4	8	12	16	20	24	28	32	36	40

4	8	12	16	20	24	28	32	36	40

Appendix F

Trios Game-Based Multiplication Fact Practice

GAME 27

TRIOS

For two players, you need: 10-sided die or deck of playing cards with face cards removed (ace = 1), one 5 × 5 game board with a multiple of 5 in each square, 15 counters in one color and 15 in another color (or two colors of markers, if the game board is laminated)

How to play: Players take turns rolling the die (or choosing a card), multiplying the number by 5, and placing a counter of their chosen color on any square with that product. The object is to cover three spaces in a row (horizontally, vertically, or diagonally) with the same color. Each successful trio earns the player five points. The person with the highest score wins. New trios can intersect but only by one number.

Possible variations: Change the size of the game board. Change the multiples on the board for other fact sets. Change to Four in a Row.

15	40	25	0	30
45	20	10	5	25
5	35	0	50	45
40	15	30	25	20
20	50	45	10	35

Appendix G

Fixed Factor War Game-Based Multiplication Fact Practice

GAME 32

FIXED FACTOR WAR

● ● ● ●

For each pair of players, you need: deck of playing cards with king and jacks removed (ace = 1, queen = 0)

How to play: Identify a factor and place a card with that number faceup in the middle. Players divide the rest of the cards equally, shuffle them, and place them facedown. At the same time, both players turn up the top card and determine the product of their card and the factor in the middle. Each partner takes turns saying the full multiplication sentence, and both decide if the products are correct. You may wish to encourage students to explain how they used halving and doubling to find the product. The player who correctly states the greater product gets both players' cards. (The middle card stays.) If there is a tie, a "war" is declared, and partners repeat the process, with the winner taking all played cards. The player with the most cards wins.

Possible variations: Play Fixed Addend War. Play for a set time. Use numeral cards instead of playing cards. Have students record their equations. (This helps with accountability.)

Appendix H

Child Assent

I will say to my students the following:

"Like you, I am a student right now. I am pursuing my Master's Degree from Minnesota State University Moorhead. As part of my school work, I have to conduct what's called 'action research'. This means I ask a question related to my teaching, then I collect and analyze data to try to answer the question."

"My question is about the best way to practice basic multiplication facts in fifth grade to promote multiplication fact fluency, which is a student's ability to quickly, efficiently, and accurately solve basic multiplication fact problems."

"To collect my data, you (if you and your guardians agree) will first complete a 3 minute multiplication probe consisting of all of the 1-9 multiplication facts. You will then practice basic multiplication facts for ten minutes each day for eight weeks. My first math class will practice multiplication facts by playing multiplication games with a partner and my second math class will practice multiplication facts on the computer using the website multiplication.com. At the end of the eight weeks, you will take the 3 minute multiplication probe consisting of all of the 1-9 multiplication facts again. That's it."

"All of this multiplication fact practice is already part of our daily math class, so whether or not your guardians consent, you will participate in this daily multiplication fact practice. What makes the difference is whether or not I can use your data in my research study. If I do have your guardian's consent I will be able to use your data. If I do not have your guardian's consent I will not use your data. Does this make sense?"

"Being part of this study will not impact your grade in this class. If you and your guardian choose to let me use your data, you can change your mind at any time. You and your guardian just have to let me know you want to withdraw from this study."

"Part of my job is to protect you and I will do that throughout my research study, too. I am the only one who will see your multiplication probes and multiplication probe scores. When I record the data and use it in my study, I will not use your name. Instead, you'll be assigned a number. I also won't say anything about you that would allow someone else to figure out it was you. Does this make sense?"

“To get your guardians’ permission, I am sending them a letter (Show students the consent letter). They need to read through this and fill it out for me. Please encourage your guardians to read the letter, fill the letter out, and return it to me as soon as they can.”

“What questions do you have about this?”

Appendix I

Consent Letter

Consent Form

Participation in Research

Title: A Comparison of Two Approaches To Promote Multiplication Fact Fluency In Fifth Grade.

Purpose: The purpose of this research is to compare the effectiveness of two basic multiplication fact practice methods, computer-based multiplication fact practice and game-based multiplication fact practice, as ways for students to practice basic multiplication facts to promote multiplication fact fluency in fifth grade.

Study information: This study will compare the growth that fifth grade students make in basic multiplication facts between two groups of students. Group A will receive 10 minutes a day of computer-based multiplication fact practice using Multiplication.com, a digital resource approved by [redacted] to promote mathematical skills. Group B will receive 10 minutes a day of game-based multiplication fact practice using games from the book, *Math Fact Fluency 60+ Games and Assessment Tools to Support Learning and Retention* by Jennifer Bay-Williams and Gina Kling. The teacher will use a baseline assessment and post-assessment to determine the average amount of growth each group made in their basic multiplication facts.

Time: The participants will complete this study during their scheduled math instruction time. This study will take place during the spring semester of 2023.

Risks: Participation in this study involves minimal risk.

Benefits: Participation may help improve the participant's basic multiplication fact fluency, the ability to quickly, efficiently, and accurately respond to basic multiplication fact problems. Therefore, increasing their ability to solve grade level math problems.

Confidentiality: Participants' identities will not be shared with anyone beyond the principal investigator, Dr. Kathy Enger, and the co-investigator, Jordyn Berger. All individual information will be recorded and tracked under an identification number and not the participant's name.

Participation and withdrawal: Participation in this study is optional. Students can choose not to participate or choose to withdraw at any time without any negative effects on grades, relationship with the instructor, or relationship with their school.

Contact: If you have any questions about the study, you may contact any of these people:

Jordyn Berger
Co-Investigator
(218)-284-8497
Email: [redacted]

Dr. Kathy Enger, Ph. D.
Principal Investigator
Assistant Professor
School of Teaching and Learning
Minnesota State University Moorhead
Email: kathy.enger@mnstate.edu

Any questions about your rights may be directed to Robert Nava, Chair of the MSUM Institutional Review Board, at 218-477-4308 or irb@mnstate.edu. You will be given a copy of this form to keep.

"I have been informed of the study details and understand what participating in the study means. I understand that my child's identity will be protected and that he/she can choose to stop participating in the study at any time. By signing this form, I am agreeing to allow my child to participate in the study. I am at least 18 years of age or older."

_____
Name of Child (Print)

_____ _____
Signature of Parent/Guardian Date

_____ _____
Signature of Investigator (Jordyn Berger) Date