Comparing iPad and Flash Card Interventions for Enhancing Math Performance in Addition and Subtraction Facts

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Comparing iPad and Flash Card Interventions for Enhancing Math Performance in Addition and Subtraction Facts

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Capstone Project: An Action Research Project

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Abstract

This action research was driven by the researcher’s interest in increasing students’ math fact knowledge. The researcher implemented both an iPad and flash card intervention to determine and compare the effectiveness of each. Two-minute addition and subtraction probes were utilized as a pre and post-test to determine growth. A student survey was also given to determine students’ interest in their respective intervention. The findings revealed that both interventions resulted in growth in both addition and subtraction facts, but there was no significant difference in growth between the two. The findings also revealed that most students found both the iPad and flash card interventions to be motivating and engaging. This research was conducted to impact future classroom practices as well as schoolwide decisions in practices pertaining to the acquisition of math facts.

Keywords: math fact fluency, addition, subtraction, iPad, flash cards, student motivation
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Math fact fluency involves the quick, accurate retrieval of basic arithmetic combinations and the ability to use fact knowledge efficiently (Baroody, 2011). According to the Common Core State Standards, Iowa students in second grade should be able to fluently add and subtract within 20 using mental strategies (Grade 2: Mathematics, 2023). By the end of second grade, students should know from memory all sums of two one-digit numbers (2.OA.B.2) (Grade 2: Mathematics, 2023). Mastering addition and subtraction facts within 20 is crucial not only as an individual skill, but also as a foundation for many other math skills that students will work to develop in the future. The problem is determining the best practices for teaching students the strategies and skills to become fluent in their math facts in a second-grade classroom.

The purpose of this action research is to examine and compare different types of math fact fluency interventions with a small class of second grade students to determine the best practice for helping students become fluent in their facts. Specifically, a flash card intervention will be compared to a game-based iPad application that uses gamification. Gamification is the use of gaming elements in a nongaming context, such as practicing math facts (Higgins & Trotman, 2019). The second component of this action research will examine student opinions and feelings regarding the respective interventions. The study aims to answer the following research questions:

1. Does practice through gamification using an iPad application result in more significant growth in math fact fluency than traditional flash cards?

2. What are students’ thoughts about iPad and flash card fact practice?

The findings of this study will be beneficial for other elementary educators as they plan activities and interventions to increase math fact fluency in their classrooms.
Comparing iPad and Flash Card Math Interventions

Research for this study and literature review utilized the DeWitt Library at Northwestern College to review scholarly, peer-reviewed journals. Most of the scholarly journals included in the literature review section have been published within the last 10 years. A few articles written before 2014 were used for foundational and historical information on fact fluency and various interventions. The primary focus when finding research studies was on elementary students learning addition, subtraction, and multiplication facts. The scope of research included various types of math fact interventions, including both paper-pencil and technology-based interventions. Additionally, the effects of gamification on student performance and attitude towards learning were researched.

Analysis of both quantitative and qualitative data within this action research will reveal the more effective intervention for this small group of students. The variance in student growth between the two experimental groups will determine which intervention was more successful. The student survey results will indicate how students feel about each intervention and whether they were motivated to improve their fact knowledge in one intervention compared to the other.

The increasing presence of various types of technology in the classroom can make it challenging for teachers to determine best practices. The literature review will explain the importance of fact fluency in overall math success and introduce various types of technology and paper-based interventions that have been previously studied. Additionally, gamifications effect on student achievement, motivation, confidence, and attitudes will be discussed. An investigation into the effects of a flash card fact fluency intervention compared to a technology and gamification-based intervention will be conducted. Finally, data will be collected on students’ feelings and attitudes towards these math interventions.
**Review of the Literature**

**The Importance of Student Fact Fluency**

Nelson et al. (2016) conducted a study to determine the extent to which growth in fact fluency predicted student performance on state math assessments. The study included 1,493 students in grades four through eight who were identified as at risk of failing to meet proficiency standards of the state math test from 70 schools in Minnesota. The study aimed to determine if there was a positive correlation between increases in fact fluency scores and state test scores in the following year. At the study’s conclusion the researchers determined that “improvements in fact fluency growth were related to overall math proficiency throughout later elementary and middle school” (Nelson et al., 2016). Findings from this study suggest that working to improve students’ fact fluency amongst elementary students has a positive impact on general math assessments through at least the eighth grade.

While Nelson et al. (2016) focused on the impact of fact fluency progress, Vasilyeva et al. (2015) explored the methods that students utilize to solve basic fact fluency problems. In their study, Vasilyeva et al. (2015) examined a group of 92 first graders from Massachusetts to identify the strategies employed by first graders when solving simple arithmetic problems compared to more complex problems. They discovered that retrieval, or automatic recall, was the most used strategy for single-digit addition problems. Furthermore, Vasilyeva et al. (2015) observed that the use of counting as a strategy increased significantly from single to mixed-digit problems and the use of decomposition increased from simple to complex problems. This study highlights the variety of strategies that students use when solving various arithmetic problems and emphasizes the importance of helping students enhance all of these skills.
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The impact of implementing automaticity drills on computational math skills and the relationship between automaticity and conceptual understanding were explored by McGee et al. (2017). Participants included 671 third, fourth, and fifth graders from three elementary schools in Kentucky. The students used an application called “MathFacts in a Flash” with the goal of improving their fact automaticity. They then took statewide standardized tests to assess conceptual understanding. Based on the results of these assessments, McGee et al. (2017) determined that there was not enough evidence to suggest that automaticity leads to proficiency. These findings further elaborate on the results of Nelson et al. (2017) by indicating that students’ future success in mathematics is not only positively influenced by basic fact fluency knowledge, but more specifically, students would most benefit from the development of process-driven automaticity rather than answer-driven automaticity.

Aspiranti et al. (2020) explored students’ performance on fluency assessments in relation to the modality used. Six students, two from each of the second, third, and fourth grades, completed six probes per modality of addition problems over nine consecutive school days. The students were also asked to indicate their preferred modality for assessment purposes. The modalities included paper-pencil, iPad with a stylus, and iPad using their finger on the screens keyboard. Aspiranti et al. (2020) found that paper-pencil modalities resulted in higher fluency scores than either iPad assessment. Additionally, all six students chose paper-pencil as their preferred assessment modality. Student quotes justifying that preference included “paper-pencil being easier to use than the other modalities” and that students “did not like the stylus because they could not rest their hand or arm on the table the way they typically would when writing on paper” (Aspiranti et al., 2020). These results are valuable when considering the most accurate method for assessing fact fluency knowledge.
Similarly, Hensley et al. (2017) examined whether student performance can generalize across different test administration modes. This study included 225 third, fourth, and fifth-grade students aged between eight and eleven. These students came from nine classrooms, with three from each grade level, in a suburban public elementary school in the Midwestern United States. Each student was given three paper-based probes and 3 computer-based probes with identical questions. Half of the classrooms gave the paper-based probes first while the other half gave the computer-based probes first. Like the findings of Aspiranti et al. (2020), Hensley et al. (2017) found that students typically performed better on the paper-based probes than the computer-based probes. Specifically in this study, researchers found that students correctly answered about 10 more problems on the paper-based probe than on the computer-based probe. These findings stress that data from one type of probe may not always directly transfer to a different type, and educators should use caution when administering different modes of assessment.

Solomon et al. (2020) used aggregated data from multiple research articles to analyze the distribution of learning rates in single skill measures, specifically focusing on digits correct per minute. The researchers calculated rates of learning per session of intervention as well as in relation to the amount of instructional time spent during interventions. Solomon et al. (2020) found that overall, students grew by about 1.60 digits correct per minute per session of intervention, while rates of learning for addition and subtraction specifically ranged from 1.00 to 2.00 digits correct per minute. This data can help determine whether student growth on digits correct per minute is significant in specific cases compared to the averages found in this study.

Types of Fact Fluency Intervention

In the realm of mathematics education, there are many different types of interventions that have been and can be used with students. McCallum et al. (2022) examined the effects of a
virtual Taped Problem Intervention (TPI) on students’ subtraction fluency. The study involved three second-grade students from the Mid-Atlantic United States during the Covid-19 pandemic. TPI involves students listening to an audio recording of math facts while following along with a corresponding worksheet. Their goal is to “beat the tape”. The intervention allows for immediate, corrective feedback that prevents students from practicing incorrect responses. In this virtual version of the intervention, students participated in five-minute one-on-one Zoom intervention sessions three times per week. In this virtual adaptation students gave verbal responses to the audio recording as opposed to a written response. McCallum et al. (2022) found that the virtual implementation of TPI procedures appears to be effective at increasing math fact fluency. Additionally, the appreciable gains resulting from this study suggest that the tactile practice of printing answers on a worksheet as in the traditional intervention may not be a necessary component for an increase in math fact fluency to occur.

Detect, Practice, Repair (DPR) is a math intervention in which students are given a pretest to determine problems for which the students lack automaticity. This is followed by practice, during which students complete a cover, copy, compare procedure with the problems that were targeted during the detect phase (Marin et al., 2019). Finally, an alternate form of the detect pretest is given to students, and their progress is charted (Martin et al., 2019). Musti-Rao and Plati (2015) compared the effects of two class wide interventions, DPR using PowerPoint and self-mediated iPad instruction called Math Drills. The study involved 12 third grade students in a suburban school district in the Northeastern United States. The researchers found that both interventions were successful, but the iPad intervention yielded larger gains. Specifically, students responded at an increasingly higher rate during each consecutive intervention session
when using the iPad application (18.5 responses per minute) compared to the DPR intervention (8.5 responses per minute).

Martin et al. (2019) also studied the impact of a modified version of DPR on improving students’ math fact fluency. The study involved four parent-student dyads, all of whom included second-grade students. Parents received training on DPR and were instructed to implement the intervention three times per week. They were tested on their fidelity of implementation and received performance feedback when fidelity was below 80%. After the intervention and assessments, researchers found that although all students showed improvements in fact fluency, only three out of the four students displayed a functional relationship for this improvement. In addition, only two of the sets of parent implementers were able to successfully deliver the intervention as intended, even with performance feedback. The results of this study, along with Musti-Rao and Plati’s (2015) findings suggest that while DPR is an effective strategy for math intervention in a school setting, a parent-implemented version at home may not be as effective.

**Effects of Technology and Digital Gamification on Student Achievement**

Technology can be utilized in various ways in today’s classrooms. Hassler Hallstedt et al. (2018) conducted a study on the direct and follow up effects of a mathematics tablet intervention. The study included 283 second graders from 27 schools in Sweden. The students were divided into four intervention groups: passive control, reading (placebo) on the iPad, mathematics drilling on the iPad, and mathematics drilling on the iPad combined with a working memory intervention. Hassler Halstedt et al. (2018) discovered that the iPad intervention effectively enhanced basic arithmetic skills among low performing second-grade students. Specifically, they found significant improvements in math fact addition 0 to 12 and subtraction 0 to 12 in the math iPad intervention group compared to the placebo group at the post-assessment. However, there
were no significant results to find any benefits of adding a 10-minute working memory training in addition to the mathematics iPad intervention.

In contrast to the technology-based drilling intervention studied by Hassler Hallstedt et al. (2018), Yeh et al. (2019) examined a technology intervention involving gamification. The study involved 215 second graders from a school in Taiwan who received intervention using the iPad game, Math-Island. Another 125 second graders from a school with similar socioeconomic backgrounds were used as the control group, receiving only conventional math instruction. Both groups took the pre and post-test after a two-year intervention to measure growth. The results showed that the “Math-Island system could effectively improve the students’ ability to calculate expressions and solve word problems” (Yeh et al., 2019). The incorporation of both the construction and sightseeing game mechanisms into the curriculum was cited as a possible factor contributing to the improvement in students’ learning achievement within the game.

Watson-Huggins and Trotman (2019) also explored the impacts of gamification on student achievement. The study included 51 sixth-grade students in Jamaica, divided into an experimental group of 35 students and a control group of 26 students. The experimental group had access to the Edufocal gaming software for two full terms of study. This software featured 15,000 preparatory questions for students to answer. Students earned points and medals for correct responses. The control group received only traditional math instruction during the same timeframe. All students completed pre and post-tests to evaluate their progress. In contrast to Yeh et al.’s (2019) findings, Watson-Huggins and Trotman (2019) discovered that test performance was similar between the two groups. These results suggest that there may not be a significant improvement in achievement when utilizing gamification compared to traditional teaching methods in math.
Yig and Sezgin (2021) conducted a comprehensive analysis of digitally constructed gamification processes in mathematics education. They gathered and documented data from 71 peer-reviewed studies. The analysis revealed that gamification has a positive effect on mathematics education. This finding supports Yeh et al.’s (2019) results, but on a larger scale and with more data. Furthermore, Yig and Sezgin (2021) note a growing trend in the adoption of a gamification approach in mathematics education.

In a study conducted by Ku et al. (2014), the effects of gamification on students with varying learning abilities were examined. The study involved 51 fourth-grade students who were divided into two groups: an experimental group that learned in a digital game-based environment and a control group that learned in a paper-based setting. After completing a computational test and confidence scale, students were then separated into subgroups based on their abilities - high-ability and low-ability - within their respective groups. Nine learning sessions were conducted for five consecutive weeks, during which the experimental group received immediate feedback through the game, while the control group received the same message after their teacher marked their worksheets. The researchers discovered that low-ability students in the experimental group showed more improvement than their low-ability peers in the control group. Ku et al. (2014) suggested that the immediate feedback provided within the game-based environment could be a key element that supports low-ability students in learning mathematics.

When considering interventions using technology, it is important to also consider how students are tested following a technology or paper-pencil intervention. Rich et al. (2017) aimed to determine if the generalization of computer gains to paper-pencil applications improved when practice included training with multiple stimulus exemplars, in the form of weekly paper-pencil practice added to a computer-based intervention. The study included 57 second graders from the
United States. They used a three-group pretest and post-test design to evaluate differences in performance within and across the assigned practice modalities. All groups participated in 20 two-minute practice sessions. One group practiced using only the computer, another group practiced using only paper-pencil, and the third group practiced using the computer for 4 days followed by 1 day of paper-pencil practice. The pretest and post-test included both paper-pencil and computer assessments for all three experimental groups. Results showed that performance did not generalize across modalities when using computer-only practice. However, incorporating multiple stimulus exemplars by replacing one computer practice session with a paper-pencil practice session resulted in adequate generalization across modalities. These findings are important, as they highlighted the need to consider the type of assessment being used when designing interventions for students.

**Effects of Technology and Digital Gamification on Student Motivation**

Technology in the classroom can have a significant impact beyond just student achievement. Student motivation and attitudes toward learning can also be influenced by technology. In a meta-analysis conducted by Higgins et al. (2019), which included 29 articles with 112 participant samples, the researchers aimed to determine the overall effect of using technology on mathematics achievement, motivation, and attitude. Data from the various studies showed that using technology in the context of mathematics has a positive influence on student achievement, attitude, and motivation. Additionally, the studies indicated that achievement, motivation, and attitudes were more strongly influenced when multiple technologies were utilized with the student.

Widodo and Rahayu (2019) conducted a study that explored technology use through the perspective of gamification. The researchers utilized a quasi-experimental design to investigate
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how arithmetic games like Beemath and Kurtacil affected the outcomes of large-scale testing and students’ perceptions of math. Third-grade students from three different schools in Indonesia participated in the study. Students underwent an initial, interim, and final test to evaluate their math skills followed by an interview after the intervention. Widodo and Rahayu (2019) discovered that the games had a minimal impact on the students’ multiplication abilities. However, they did find that the students’ responses to the interview questions supported the notion that gamification positively influences students’ perceptions of math. Specifically, “94% of students thought they were more focused on their learning, 83% did not get tired of learning, and 100% felt they had a better understanding of multiplication as a result of the games” (Widodo and Rahayu, 2019).

Yeh et al. (2019) conducted a study in which students were instructed to use an application called Math Island on their tablets both at home and at school, in addition to regular teacher-led instruction. The study included 215 second graders from two similar schools in Taiwan. After the intervention, students were tested to measure academic growth and were asked to complete an interest questionnaire. They also participated in interviews to share their thoughts on the Math Island game. The results of the questionnaire and interview were consistent with Widodo and Rahayu’s (2019) findings regarding student interest. Yeh et al. (2019) discovered that students who used the Math Island system maintained a high level of interest in learning mathematics through the system.

Specifically examining the effects of gamification on students with different abilities, Ku et al. (2014) investigated the influence of game-based learning on students with varying math abilities. In their study of 51 fourth graders, students were divided into control and experimental groups, which were then further divided into two subgroups based on high-ability and low-
ability. Students in the experimental group learned via two main virtual competition mini games: Battleship and Math Kicker. Results showed that game-based learning might help students with different levels of ability to improve confidence in mathematics. Characteristics of game-based learning that enhanced students’ confidence and performance were identified as “specific goals, immediate feedback, and various levels of challenge” (Ku et al., 2014).

Ok and Bryant (2016) took a step further by analyzing the impact of gamification on motivation and attitudes among students with learning disabilities. This study involved four fifth-grade students with learning disabilities from two elementary schools located in central Texas. In this study all four participants took part in the iPad application intervention. They used an application called Math Evolve, in which students solve problems to fight against enemies coming down from the top of the screen, for 15 thirty-minute sessions. Following observations and student interviews, it was determined that the intervention appeared to motivate students and engage them in learning. Ok and Bryant (2016) also highlighted that students thought that the iPads supported their learning of math facts and motivated them to practice more. Elements as described in Ku et al.’s (2014) research about gamification components such as specific goals, immediate feedback, and various levels of challenge may have contributed to students’ overall positive feelings around the iPad game.

Yig and Sezgin (2021) conducted a meta-analysis on the impact of digital gamification on student achievement and motivation. They collected, recorded, and coded data from 71 studies for analysis. The results of the studies showed that a digital gamification approach is primarily effective in enhancing student motivation. These results are consistent with Ok and Bryant’s (2016) research and Higgins et al.’s (2019) findings, which also highlighted student motivation as a key benefit of utilizing gamification in math.
Methods

Participants and Research Site

The action research study took place at a rural elementary school in Northeast Iowa. The school serves students from Junior Kindergarten through sixth grade and has a total enrollment of 273 students. The student body is made up of 47% male and 53% female students. The racial composition is 96% Caucasian, 2.6% Hispanic, 0.4% African American, and 1.1% multi-racial. Additionally, 35.5% of students are enrolled in the free and reduced lunch program. The research specifically focused on a second-grade classroom with 19 students, including 8 boys and 11 girls, all Caucasian and aged 7 or 8. Following institutional review board procedures, this study was deemed exempt, as the data collected was considered typical for the classroom, and no specific identifiable information about any student was obtained.

Intervention and Timeline

All 19 participants were given two pretests: one containing 104 addition facts and the other containing 104 subtraction facts. Each of these pretests was timed for two minutes. The pretest was scored based on correct answers, and the percentage of correct answers out of questions completed was also calculated. Following the collection of the pretest data, the 19 students were split into two experimental groups with considerations made for an equal split of low, middle, and high achieving students based on the results of the pretests.

The control group, consisting of nine students, participated in flash card practice, while the experimental group, consisting of 10 students, participated in an iPad application intervention using the iPad application called Monster Math. Prior to the three-week-long intervention period, both groups were given explicit instruction on how to complete the practice with fidelity, followed by a six-minute practice intervention session using their assigned intervention.
The flash card control group was given a Ziploc bag labeled “bad” containing flash cards with addition facts with answers within 20 and subtraction facts with answers within 20. They were also given an empty Ziploc bag labeled “good”. The students were instructed to grab a few flash cards at a time from the “bad” bag and answer the question from each flash card one at a time, being sure to check the corresponding answer on the back of the card. If they answered the question correctly, they could put it in the “good” bag. If they answered the question incorrectly, they were instructed to return that card to the “bad” bag. Students repeated this process for the duration of the six-minute intervention session. The sessions were completed four times a week for three weeks.

The experimental group was instructed to use the iPad application called Monster Math and click on the Math Adventure game at the start of each intervention session. This game involved the student being prompted to find all equations that equal a specific number. For example, the top of the screen may say “Equal to 10” and the students were tasked with clicking on the pieces of candy that have a math fact that is equal to 10. At each level’s end, students received stars and were sent to the next level. This group of students also participated in a six-minute practice session followed by an intervention period of three weeks with four six-minute intervention sessions per week.

Following the three-week intervention period, students completed the same two-timed tests that were completed as pretests before the intervention. Additionally, both groups participated in a short survey to gain perspective on students' thoughts and feelings towards the iPad intervention.
Variables and Measures

The variables in this intervention include the control variable of the timed pre and post-tests that were given to both groups of students. The addition and subtraction timed pre and posttests that were used for the action research were generated using the website Mathfactcafe.com. The independent variables in this study were the flash card intervention for the control group and the Monster Math iPad intervention for the experimental group. Both groups completed their respective interventions at the same time of day for six minutes, twelve times over a three-week period. The addition and subtraction timed pre and post-tests that were used for the action research were generated using the website Mathfactcafe.com.

Data Collection

For this action research the data collected was both quantitative and qualitative. The quantitative data included a two-minute timed addition pretest and timed subtraction pretest. The tests were auto generated using a website called Mathfactcafe.com. Scores from the pretests were collected and scored for the number of answers correct and accuracy percentage. Following the three-week intervention period the same tests were given as post-tests and were scored in the same manner. The qualitative data was collected via a paper survey in which students answered questions pertaining to their respective intervention.

Anticipated Statistical Analysis

All pre and post-test data was collected and scored based on the correct answers given and the percentage of answers out of completed questions. The data was stored in an Excel spreadsheet. Following the post-test, all quantitative data was analyzed using a four-way factorial means test. The level of significance used for these tests is $p \leq .05$. The tests will determine
whether both groups improved from pretest to post-test and compare the performance of both groups on the post-test, following the intervention.

The responses from the student interviews following the intervention were qualitatively analyzed for common trends and themes in answers.
Data Analysis

Since the students were divided into two experimental groups of students, one participating in iPad intervention and the other in flash card intervention, an independent samples t-test was conducted separately for addition and subtraction facts to determine whether there was a significant difference in the two groups prior knowledge prior to the respective interventions. Addition fact pretest mean scores for students who participated in the iPad intervention (M = 30.8, SD = 10.94) and the flash card intervention (M = 33, SD = 10.73) showed no significant difference, \( t (15) = -0.196, p = 0.846 \). Subtraction fact pretest mean scores for students who participated in the iPad intervention (M = 19.5, SD =11.02) and the flash card intervention (M = 24, SD = 13.81) showed no significant difference, \( t (15) = -0.633, p = 0.536 \). Students started the intervention at an academically equivalent level in prior knowledge of both addition and subtraction facts.

Two dependent samples t-tests were conducted to determine whether students who participated in the iPad intervention had different pretest and post-test mean scores on the addition and subtraction fact probes. Students in the iPad intervention group showed significant growth in their addition fact knowledge between the pretest (M = 30.8, SD = 10.94) and the post-test (M = 37.6, SD = 15.50), \( t (8) = -2.571, p = 0.033 \). Conversely, students in the iPad intervention did not improve significantly in their subtraction fact knowledge between the pretest (M = 19.5, SD =11.02) and the post-test (M = 21.5, SD = 14.87), \( t (8) = -1.367, p = 0.208 \). These results reveal that students who participated in the iPad intervention showed significant growth in their addition fact knowledge, but not their subtraction fact knowledge. Results from the pretest and post-test probes for the iPad intervention group can be found in Chart 1 (addition facts) and Chart 2 (subtraction facts).
Additional dependent samples t-tests were also conducted to determine whether students who participated in the flash card intervention had different pretest and post-test mean scores on the addition and subtraction probes. Students in the flash card intervention group showed significant growth in their addition fact knowledge between the pretest ($M = 33, SD = 10.73$) and post-test ($M = 38.22, SD = 13.14$), $t (7) = -3.076, p = 0.017$. Similarly, students in the flash card intervention also showed significant growth in their subtraction fact knowledge between the pretest ($M = 24, SD = 13.81$) and post-test ($M = 27.66, SD = 13.37$), $t (7) = -4.347, p = 0.003$. This analysis shows that students who participated in the flash card intervention significantly improved both their addition and subtraction fact probe scores. Results from the pretest and post-test probes for the flash card intervention group can be found in Chart 3 (addition facts) and Chart 4 (subtraction facts).

Finally independent samples t-tests were conducted to determine whether one intervention group produced different results than the other on their mean addition and subtraction post-test scores. There was no significant difference in addition fact post-test mean scores between students in the iPad intervention group ($M = 37.6, SD = 15.50$) and the flash card intervention group ($M = 38.22, SD = 13.14$), $t (15) = 0.152, p = .881$. There was also no significant difference in subtraction fact post-test scores between students in the iPad intervention group ($M = 21.5, SD = 14.87$) and the flash card intervention group ($M = 27.66, SD = 13.37$), $t (15) = -0.735, p = 0.473$. These findings indicate that while students in both intervention groups showed significant growth in addition facts and only flash card group showed significant growth in subtraction facts, student outcomes were not significantly different based on which intervention the students participated in.
Qualitative data from student surveys in both groups revealed similar insights into students’ interest and motivation in participating in the interventions. In the iPad intervention group, nine out of ten students answered “yes” to the statements, “The iPad practice was fun” and “I was excited/motivated to practice my math facts using the iPad.” One student in the iPad group marked “no” to both statements. In the short answer section of the survey students in the iPad group mentioned that they liked the fact practice on the iPad because “you got to beat monsters” and “I got candy and got to see the animals.” When asked what they did not like about the iPad practice, they responded with “it was hard” and “it would tell you the answers.”

Similarly to the iPad intervention group the flash card intervention group had nine out of nine students respond with a “yes” to both statements mentioned above. Students mentioned that they liked how the flash cards helped them “get smarter,” “learn their facts,” and “get better at math.” Only one student mentioned something they did not like about the flash cards, stating that “it was boring.” This qualitative data indicates that students in both intervention groups were generally motivated and excited to practice their facts. Additionally, they found their respective interventions to be fun.
Chart 1

*Pretest and post-test addition fact scores for students in the iPad intervention group bar graph.*

![Chart 1: iPad Intervention - Addition Facts Correct in 2 Minutes](image)

Chart 2

*Pretest and post-test subtraction fact scores for students in the iPad intervention group bar graph.*

![Chart 2: iPad Intervention - Subtraction Facts Correct in 2 Minutes](image)
Chart 3

*Pretest and post-test addition fact scores for students in the flash card intervention group bar graph.*

![Flash Card Intervention - Addition Facts Correct in 2 Minutes](chart)

Chart 4

*Pretest and post-test subtraction fact scores for students in the flash card intervention group bar graph.*

![Flash Card Intervention - Subtraction Facts Correct in 2 Minutes](chart)
Discussion

Summary of Major Findings

This action research study on the implementation of two different types of math fact practice interventions, flash cards and iPad practice, resulted in growth for both groups of students in both addition and subtraction from the pretest to the posttest. There was no significant difference in growth between the two intervention groups. Since the groups were also split with a mixture of high and low achieving students in each, the results align with those of Ku et al. (2014) where both high and low ability students benefited from embedding learning materials into digital games. The lack of significant difference in a digital gamification approach compared to a control group correlates with Widodo and Rahayu’s (2019) findings that there was a very small influence of the application of the game models to students’ multiplication ability. Watson-Huggins and Trotman (2019) also found test performance to be at the same level regardless of which group, gamification software or control group, students were in.

Additionally, results from the student surveys taken after the post-test revealed that all but one student in the iPad intervention found it fun, engaging, and motivating. In the flash card group, all students responded that the intervention was fun, engaging and motivating. This data reveals that students were engaged and interested in their respective interventions, which may have contributed to the significant growth in their math fact knowledge. These results around the motivation of gamification interventions align with many other researchers’ findings. Specifically, Ok and Bryant (2016), Higgins et al. (2019), Yeh et al. (2019), and Ku et al. (2014) all identified similar findings to this action research, showing that digital gamification or the use of technology to practice math resulted in a high level of interest and motivation for an overwhelming majority of students.
The lack of a significant distinction in data around test scores or students’ feelings toward a specific intervention, showing the benefit of one intervention over the other, suggests that student choice may be the logical next step. Since both interventions were proven effective, allowing students to choose how they practice their facts may help to keep them motivated and interested in their chosen intervention.

Limitations of the Study

The class that participated in this action research consisted of only nineteen students. A larger sample size would have been more beneficial for this type of research, as it would have provided more data for analysis and comparison. Time was also a constraint in this research, as the intervention period was only three weeks. Since math facts are a year-long focus in second grade, a longer intervention period could have offered a more realistic depiction of the results that these interventions may yield on a larger scale.
Future Research

Further research would be helpful in revealing a more thorough picture of the impact of both flash cards and technology-based math fact interventions. A similar study could be conducted with a larger group of students, potentially involving students across different grade levels and classrooms. This would provide more data to help determine the effectiveness of these types of interventions.

Also, research on these interventions could be extended to cover a longer period of time. A longer intervention period could not only show more growth, but potentially reveal more significant differences in scores between the two groups. Moreover, a longer research period could enable future researchers to implement a crossover design of research, wherein the control and experimental groups are tested halfway through the intervention period and then switch to the opposite intervention in the second half. This type of research design may eliminate the possibility of unbalanced groups leading to unreliable results.

Furthermore, this research could focus on multiplication and division facts instead of addition and subtraction. It could involve students from various grade levels with different background knowledge and starting points. Overall, continuing to study these math interventions and their effects over a longer period and with a broader range of subjects would be beneficial in understanding their true outcomes and impact.
Conclusion

The purpose of this action research was to examine and compare different types of math fact fluency interventions, specifically flash cards and iPad-based, with a small class of second grade students to determine the best practices for helping these students become fluent in their math facts. Students were divided into two groups participating in different interventions, and pre- and post-test math fact data were collected using timed addition and subtraction fact worksheets.

The literature review of this study explored the importance of fact fluency, the types of fact fluency interventions, and the effect of technology and digital gamification on student achievement and motivation. The literature review emphasized the significance of fact fluency in students’ future math success. Additionally, many researchers found that although students seem to be very motivated and engaged in interventions involving technology, there was not a significant difference in student achievement when using technology versus more traditional practice methods that didn’t involve technology.

Data analysis of this action research yielded similar results to those included in the literature review. It revealed that although students in both intervention groups showed significant growth in both addition and subtraction facts, there was an insignificant difference in growth when comparing the two groups. Additionally, when discussing student motivation, data analysis revealed that all but one student within both groups were motivated and interested in their respective interventions. These results provide further evidence of the importance of conducting math fact interventions and practice as well as highlighting that there is not generally a significant difference in results based on the type of intervention. These conclusions can help educators make future decisions about fact fluency interventions.
References


Comparing iPad and Flash Card Math Interventions


