MULTIPLICATION: JUST THE FACTS

A CASE STUDY ON THE EFFECTS OF VIRTUAL FLASHCARDS AND ONLINE GAMING ON RETENTION OF BASIC MULTIPLICATION FACTS

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Literature Review:

One of the biggest foundational learning challenges in elementary mathematics is developing fluency of the basic 0-12 multiplication facts (Wong & Evans, 2007). Basic multiplication facts form the basis for learning a variety of other mathematical skills including multi-digit multiplication, division, fractions, decimals, and proportions.

Fluency of these facts involves a progression of higher-order thinking skills and is described as happening in three successive phases (Baroody, 2006; Kling & Bay-Williams, 2015; Rave & Golightly, 2014). Phase one involves modeling or counting to determine the answer. Phase two involves deriving the answer using reasoning strategies and critical thinking, and phase three is automatic retrieval or mastery of the facts (Baroody; Kling & Bay-Williams; Rave & Golightly). In order to reach fluency of multiplication facts, students must first develop a conceptual understanding of multiplication. It is essential that students learn a variety of reasoning strategies for solving multiplication facts so they are able to derive an answer when needed.

Teachers must incorporate a variety of learning strategies to motivate students and to improve their conceptual understanding of multiplication (Kling & Bay-Williams, 2015; Woodward, 2006). According to Ok and Bryant (2016), the use of web-enhanced mathematics instruction has received widespread endorsement from agencies such as the National Council of Teachers of Mathematics as it provides more opportunities for student practice, feedback, and conceptual development. Technology-based multiplication instruction keeps students engaged in the learning process (Williams, 2000). As student engagement increases, the motivation for continued learning increases as well.

Theoretical Framework:

The integration of 1:1 tablet technology within the classroom provides a variety of new learning opportunities, giving students more motivation and control over their own learning (Pitler, Hubbell & Kuhn, 2012). According to Piaget, learning is an active process where students construct their own representations of knowledge (Applefield, Huber, & Moallem, 2001). Such opportunities challenge students to think analytically, critically, and collaboratively in ways that perhaps they have not done so before (Pitler, Hubbell & Kuhn). In the constructivist approach, teachers act as a guide or resource, rather than sole source, for a student's learning. Students actively construct knowledge in environments where they are allowed to be self-regulated learners, rather than in environments where they passively receive information (Brophy, 2010). Vygotsky's (1978) sociocultural theory of learning notes that the teacher should facilitate learning as the student becomes more successful with increasingly complex tasks and gains competence. Technology-enhanced lessons enable students to become actively engaged while promoting effective differentiated and individualized learning. By allowing students the option to choose from a variety of teacher-selected web applications and sites, students are given a sense of ownership in their own learning.

Participants & Selection Process:

This action research study was conducted in a third grade mathematics classroom. Two classes of twenty students each were involved in this study. One class acted as a treatment group, while the other class acted as a control group. The two classes involved were selected because they are very similar in make-up, with similar numbers of high, average, and low-performing students. Four of the low-performing students in the treatment class received special education services, whereas the low performing students in the control class did not receive such services. This small difference between the two groups could have caused the treatment group to not perform as well as their peers in the control group. Within the treatment class, I randomly created two focus groups of ten students each. One group was assigned to work only on virtual multiplication flashcards and the other group was assigned to work only on online multiplication games for twenty minutes daily during the course of this study. The students in this class are representative of the entire grade level, with an even number of males and females. The mathematics ability levels of students in this class range from first grade to fourth grade levels.

Methods & Methodology:

This study employed an evaluative mixed-methods approach using objective assessment data and constant comparative method (Creswell, 2014). My research focused on the following guiding question: "Do third grade mathematics students make greater gains in learning 0-12 multiplication facts when using virtual flash cards or when they are allowed to play teacher-selected online multiplication games using 1:1 tablet technology?"

I completed this research project before beginning my unit on multiplication. I purposefully conducted this research in isolation of other multiplication instruction to avoid outside factors that could potentially skew results.

Method	Purpose	Tools	Time/Frequency
Virtual Multiplication Flashcards	To determine if consistent practice with virtual flashcards significantly impacts the learning of basic multiplication	• 1:1 tablets • Printed multiplication fact sheet • Edmodo site with links to virtual flashcards	Twenty minutes each day (Monday – Friday) for two weeks
Online Multiplication Games	To determine if consistent practice with online multiplication games significantly impacts the learning of basic multiplication	• 1:1 tablets • Printed multiplication fact sheet • Edmodo site with links to teacher-selected multiplication review games	Twenty minutes each day (Monday – Friday) for two weeks
Multiplication Pre/Post Tests	To determine fact proficiency before and after treatment	• Multiplication fact pre/post test with 100 questions (Untimed)	• Pretest: Given on Day 1 • Posttest: Given on Day 10
Student Interviews	To determine conceptual understandings and/or misconceptions	• Paper • Pencil	• Twenty minutes for two days immediately prior to the start of the study • Twenty minutes per day on Days 11, 12, & 13

Data:

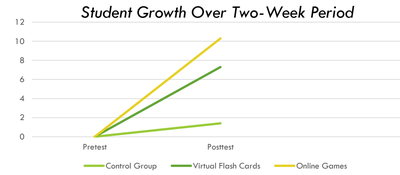
Quantitative Data Collection: On Day 1 of the study, I administered a one-hundred question multiplication quiz (pretest) to all students. After the two weeks of focused multiplication practice, I administered the same quiz (posttest) to the treatment groups and the control group. I calculated the average increase/decrease in student test scores to determine if the use of virtual flash cards or online multiplication games impacted student learning. I administered the posttest to the control group to compare results with students who had no computer-based (or other) multiplication practice.

Qualitative Data Collection: I collected qualitative data by surveying students in both focus groups and the control group regarding their specific attitudes about basic multiplication fact fluency as well as about their conceptual understanding of multiplication. I met with all students in the two classes individually and/or in whole group before and after this study to ask several open-ended questions in order to gauge understanding. The answers to these questions provided insight into each child's growing conceptual understanding of multiplication. This data, along with the quantitative data, provided me with a better understanding of students' overall understanding of basic multiplication.

Results:

Finding 1: Students improved their fluency of multiplication facts by using virtual flash cards and by playing online multiplication games.

I administered a 100 fact multiplication pretest on the first day of this study and later used the same quiz as a posttest to determine if students made any significant gains as a result of practicing multiplication using either virtual flash cards or online games. Students who used the virtual flashcards to practice multiplication facts had an average growth of 7.3 points (n = 10). Students who used only online multiplication games had an average growth of 10.3 points (n = 10). The control group (n = 20) did not participate in any type of multiplication practice during this two-week period. The average growth of this control group was 1.4 points.



Finding 2: Students' confidence improved as their conceptual understanding of multiplication increased.

At both the beginning and end of this research project, I asked students questions to measure their conceptual understanding of multiplication. At the onset of this project when I asked such questions, students' responses were quite varied. Pretests indicated that many students thought multiplication and addition were synonymous. Two students even wrote notes on their papers that read, "I don't know multiplication" and "I can't do this." By the end of the two-week project, conceptual understanding had greatly improved as evidenced by students solving problems by drawing sets of tally marks/counters on their papers or using repeated addition to help them solve unfamiliar problems. Also, these students were able to apply their knowledge to solve problems that they did not know by memory. Before I graded the posttests, I asked students how they felt about their performance on the tests. It was clear that their confidence level had improved, as most all students in the focus group were excited and wanted me to grade the tests immediately. Students in the control group however, who had no multiplication practice at all during the two-week period, were frustrated as they struggled to complete the post tests. These students were much less eager, less motivated, and less confident in their abilities than those students in the focus groups.

Implications:

For Teaching

- Tablet-based online practice of multiplication skills through both virtual flash cards and online multiplication games is effective for building fluency.
- Online practice justifiably aids in improving fact fluency for many third grade students.
- Virtual flashcards and multiplication game sites can effectively differentiate lessons and provide enrichment in order to accommodate all learners.

For Future Research

- Examine data over longer period to determine if this trend would continue over time or if the gap in scores between students using virtual flashcards and online multiplication games would eventually close.
- Incorporate time limits on pre/post tests to determine if students have reached Phase Three (automatic retrieval or mastery) of multiplication fact fluency (Baroody, 2006; Kling & Bay-Williams, 2015; Rave & Golightly, 2014).