iTouces in the Classroom, Do They Contribute to Student Achievement in Math Fluency?

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Keywords
Digital native, iGeneration, 21st Century Learning, technology, iTouch, app, math facts, motivation, fluency, math, multiplication, division

Abstract
This study examined student practice of math facts with iTouch applications to determine whether the iTouch applications motivated students, and, subsequently, increased practice time and response accuracy on timed math fact tests. This study compared the current class’ overall performance on math fact fluency (speed) tests, using iTouches to previous class’ performances on the same tests, using other practice methods. The results showed the 77 percent of the class presented here achieved math fact fluency whereas the average for past years’ classes was 66 percent. Students reported the iTouches motivated their practice of math facts.

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Introduction

I teach third grade at an elementary school in Westerville. I have been teaching for five years, and I am amazed at the rapid expansion of digital technology and its various applications. My students are also fascinated with technology, and they appear to be more engaged and motivated when using it. With the development of the iTouch and the many applications I saw an opportunity to merge my two loves: teaching and technology. Moreover, a colleague of mine was able to integrate a set of iTouches seamlessly into her class environment, and the engagement of the students was refreshing to observe. I wanted to explore the use of iTouches as a pedagogical tool to enhance math fact fluency. The main question, guiding this teacher research study was, *does the use of the iTouches contribute to student achievement in math fact fluency?*

In third grade, students learn multiplication and division concepts and are expected to be fluent in basic math facts (i.e., factors up through nine) by the end of the year. In the past, approximately one-half to two-thirds of my students mastered their facts (i.e., solve with accuracy and automaticity); however, there were always several students who did not achieve fluency by the end of the year. Math fact fluency is one critical component to building the foundation for math achievement. The National Mathematics Advisory Panel (NMAP) (2008) reported, "...procedural fluency and automatic (i.e. quick and effortless) recall of facts..." (NMAP, p. xii) make up one of six elements to mathematics achievement.

Technology is changing our society at an accelerating rate. With the new and evolving nature of digital mediums, students today have more avenues for learning outside the classroom than any other generation before it. New hardware such as the iTouch and iPad are now relatively cost effective options for learning and teaching. Experts have compared this technology revolution (sometimes referred to as the digital revolution, information revolution, or knowledge revolution) to the Industrial Revolution, and just as our educational system changed substantially during that time, some educators believe it must undergo another significant transformation toward technology today (Collins & Halverson, 2009).

So, in what ways should math fact learning and technology be integrated in a third grade classroom? In my classroom, students have used various methods to practice their math facts. Traditional drills and the use of flashcards have been common means of practicing math facts. Likewise, each student keeps a math log to record his or her method of practice and the practice time. One challenge with math fact development is sustaining the students’ motivation to practice and learn math facts. Perhaps traditional drills and flashcards do not appeal to

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*It is crucial for students to master their facts to allow for concentration on higher-level and more complex concepts and skills.*

_— National Mathematics Advisory Panel, 2008_
some of the digital learners of today. Using iTouches and the variety of math apps that are available may sustain the focus and motivation of today’s learners. This article explores the broader question about the use of technologies as a motivational tool, and, specifically, the role of iTouch applications in student achievement of math fact fluency.

**Literature Review**

Technology has changed the way we live. Our methods of communicating, interacting, and even shopping have dramatically shifted due to the advent of the computer and major advances in other technologies. People are texting, emailing, Internet surfing, tweeting, and using social media everywhere, and this is more prevalent in the younger age groups than any others (Collins & Halverson, 2009; Rosen, 2010, 2011; Prensky, 2010).

Unfortunately, our educational system is still rooted in the technological past. According to Collins and Halverson (2009), education and learning methods are changing, but these changes do not appear to be happening inside the classroom. Rosen (2010) stated, “Education has not caught up with this new generation of tech-savvy children and teens. It is not that they don’t want to learn. They just learn differently” (Rosen, 2010, p. 3). The National Science Foundation Task Force on cyberlearning points out that even with all the technological advances in many of the science and communication fields, classrooms, textbooks, and instruction look very much the same as those of our parents (Rosen, 2010). The gap between traditional classroom practices and the current “tech-savy” students is widening.

**Our Students as Digital Learners**

Today’s students are considered “digital natives,” whereas their teachers and parents are known as “digital immigrants.” Marc Prensky coined these terms in the late 1990s. He noticed children growing up in the digital age developed their own language (e.g., “google it”, text acronyms and abbreviations, “facebook me”), societal norms, and, in essence, their own digital culture (Prensky, 2010). Rosen (2010) refers to these children as the “iGeneration.” The previous generation, also known as the “Net” generation, was born in the 1980s and early 1990s and grew up as the Internet and the World Wide Web increased in popularity. The iGeneration, or children and teens that are in elementary, middle and high schools, presently, are growing up with the explosion of mobile computing (e.g., cell phones, mp3 players, iTouches, smartphones). They do not know a world without easy access to information.

**The Use of Electronic Games for Learning**

These “digital natives” also spend an considerable amount of time playing electronic games (Prensky, 2010). Games have always been appealing to kids, but the accessibility of these games on computers, gaming systems (e.g., the Xbox 360, Sony Playstation 3, Nintendo
DS, Nintendo Wii), and mobile devices (such as cell phones, iTouches, and iPads) make it possible for kids to play “whatever, whenever, wherever” (Rosen, 2010). Thai, Lowenstein, Ching, and Rejeski (2009) contends use of these digital games in the classroom “offer [s] a promising and untapped opportunity to leverage children’s enthusiasm and to help transform learning in America” (Thai et al., 2009, p. 6). Halverson and Smith (2009) reframed these kind of games as “technologies for learners,” creating a whole new avenue of options for our educational system. In short, electronic games may be an effective tool to stimulate opportunities for learning math facts.

Due to the relatively recent explosion in gaming, few studies have been conducted on the effects of using electronic games in the classroom; however, there are some data on the effect of academic games on learning. Haystead and Marzano (2009) did a meta-analysis of 329 independent action research projects that studied fifteen instructional strategies with the use of games. These projects took place in 38 schools between fall of 2004 and spring of 2009. One of the instructional strategies tested was incorporating academic content in game-like situations. In a separate report of the same meta-analysis, Marzano (2010) stated that in the 60 studies he analyzed, there was an average 20-percentile point gain in student achievement when using academic games in the classroom.

Educational theorists agree we must find a way to utilize these technological tools, including electronic games, in the classroom (Collins & Halverson, 2009; Halverson & Smith, 2009; Prensky, 2010; Rosen, 2011). In addition, our educational system must change to incorporate these new tools and advances so that learning, and, consequently, student achievement, improve to meet the demands of an increasingly technical society.

Mathematics Learning in the United States

Data from international achievement tests in mathematics have generated much concern in the United States. The Trends in International Mathematics and Science Study (TIMSS) provides information on how American fourth, eighth, and twelfth graders compare to students in other nations, including our major trading partners (Gonzales et al., 2008). This study collected data in 1995, 1999, 2003 and 2007. In 1995, U.S. eighth graders scored below the international average, whereas U.S. twelfth graders scored among the lowest of 21 participating countries. The average scores of our advanced mathematics students did not outperform any other country (National Center for Education Statistics, 1999). The last TIMSS study in 2007 showed considerable gains of American students, but the American students did not perform at the highest levels (National Mathematics Advisory Panel, 2008). Clearly, the results were not consistent with our standing as a world leader in scientific and technological innovation.

Several major initiatives emerged from the TIMSS data. These initiatives led to recommendations for reforms in mathematics curriculum and standards and an increased agenda in research for achievement and skill progression in mathematics. As a result, a framework for 21st century learning skills was developed and the National Mathematics Advisory Panel (NMAP) wrote Foundations for Success, a report containing specific recommendations on math improvement (NMAP, 2008).
The NMAP report (2008), *Foundations for Success*, relied on the best available scientific evidence to recommend practices and improvements in many different elements of mathematics. Some of these elements included curriculum, learning processes, teacher education, instructional practices, assessments, and research policies pertaining to mathematics.

The report also identified the areas for improvement in mathematics learning, and algebra was one of the report’s chief concern. “The sharp falloff in mathematics achievement in the U.S. begins as students reach late middle school (i.e., eighth grade), where algebra course work begins” (NMAP, 2008, p. xiii). Indeed, algebra is considered a “gateway” to higher-level mathematics and later achievement. In fact, the NMAP reported, “students who complete Algebra II are more than twice as likely to graduate from college compared to students with less mathematical preparation” (NMAP, 2008, p.xiii).

The building blocks to success in algebra start in much earlier grades. The NMAP (2008) recommended focusing on three sets of skills and concepts to give students a proper foundation for success in algebra. First, students must demonstrate fluency with whole numbers, with a strong grounding in number sense. Second, they must demonstrate fluency with fractions, and, finally, they need to understand particular aspects of geometry and measurement. The Panel found American students do not reach automaticity with single digit addition, subtraction, multiplication and division with whole numbers as early as children do in other countries.

The importance of math fact automaticity has been researched and documented. For instance, cognitive psychologists (e.g., Delazer et al., 2003) discovered a shift in brain activation patterns as math facts are learned. Math fact processing moves from a quantitative area of the brain to one related to automatic retrieval as the facts are learned. This allows students to focus on learning more advanced math concepts. “If a student constantly has to compute the answers to basic facts, less of that student’s thinking capacity can be devoted to higher-level concepts” (Hasselbring, 2005, p. 4).

Wilson (2011) completed an extensive study of math standards across the U.S. and found a disturbing lack of priority on basic arithmetic, stating, “only 12 of 52 [sets of] state [standards] require quick recall of multiplication tables” (Wilson, 2011, p.71). This lack of emphasis within our curriculum is one reason for students’ poor fluency, but other reasons include the quantity and quality of practice and parental involvement in mathematics learning (NMAP, 2008).
Math Fact Fluency with Current Technologies

For the purposes of the present study, I focused on improving student math fact fluency with increased practice time through the use of math games and iTouch applications, yet I only found one empirical study that examined the use of iTouch for math learning. Perez (2010) reported the use of iTouch as a positive learning tool with fourth-grade students who had failed the math portion of Florida’s Comprehensive Assessment Test (FCAT). Perez (2010) referenced the engaging and motivational aspects of gaming and technology as possible reasons for the positive results.

In another study of math fact practice and the use of computer software, the results indicated significant gains in basic math facts and concepts were made in the fourth, fifth, sixth, and ninth grade students (Hudson, et al., 2010). While not a study about iTouch, the use of computer software in the study demonstrated the power current technologies have as tools for enhancing learning and improving math fact development.

I anticipated the motivational aspects of students using the iTouch math applications would increase both the quantity and quality of the practice. According to Ohio’s Academic Content Standards in mathematics, third-grade students should know all four basic operations (addition, subtraction, multiplication, and division) and should be fluent in all four by the end of third grade. In previous years, only 60% to 70% of my students demonstrated this level of math fact fluency.

Context

This study was conducted in a traditional, predominantly white, suburban elementary school located in Central Ohio. The elementary school is part of an upper middle class neighborhood. Achievement test results have been generally positive at the school. Last year, the Ohio Department of Education (ODE) gave the school an “Excellent with Distinction” rating, meaning it met all academic indicators set by ODE in all grades. The passing rate of third grade students in math for 2009-2010 was 93.9% and the fourth grade passing rate in math was 93.9% of students, whereas the fifth-grade passing rate in math waa 86.3% of students (http://ilrc.ode.state.oh.us/schools/). The school also made Adequate Yearly Progress (AYP), as defined by the state, in 2009-2010 in all reported demographic categories.

In my classroom during the year of the study, I had 22 students: nine boys and 13 girls. One student was an English language learner. One of my students had an Individualized Educational Plan (IEP) and received additional support from our intervention specialist. Six students had been identified as gifted in mathematics, but they did not receive additional services outside the classroom.
Intervention

I chose to use the iTouches and several math applications in my classroom to target math fact fluency. In addition, the iTouch has the ability to connect to the Internet even though we did not use it for this study. All the students in the class had access to the devices at least once a week, and they used them to practice math facts for two, 25-minute periods during their assigned days. They were also expected to practice 15 minutes at home every night, five days a week and to keep a math log to document the practice time.

Math fact fluency tests were given every week, and the students tracked and graphed their own scores. Tests consisted of 100 randomly generated math facts that needed to be answered in five minutes. Math fact fluency was defined as automatic recall (Hasselbring, 2005; NMAP, 2008; Wong & Evans, 2007) and the desired fluency rates ranged from supplying a correct answer in one to four seconds (Crawford, n.d.; Damer, 1997). This range is based on a pencil and paper test, so the rate also depends on the writing speed of the student (Damer, 1997). In addition, fluency for this study was defined as 80 to 100 facts answered correctly in the five minutes, which equated to students providing an answer each 3 to 3.75 seconds.

I used four different fluency test levels in order of increasing difficulty to provide a scaffolded approach to learning the facts. As the students mastered one level by answering 80 to 100 math facts correctly, they would move on to the next level. This allowed them to focus on mastery at one level before moving on to a more difficult level. The math fluency test levels were as follows: multiplication facts with factors up through nine, multiplication facts with factors up through 12, division facts with factors up through 10, division facts with factors up through 12, and mixed multiplication/division facts with factors up through 12.

By April, after several weeks of practice with the iTouch applications for math facts, most of the students were demonstrating progress with math fact fluency; however, five students showed no distinguishable difference in the scores over a three-week time period. I targeted these students as needing more concentrated practice using the iTouches.

At this point in the study, I modified the instructional focus to give striving math students additional time to practice their math facts with the iTouch. The students were among my lowest achievers in math. The intervention for these five students included adding an additional 20 to 30 minutes a day of practice using the iTouch applications. The students had the option of using three different applications. One was a drill and practice type called Instant Interactive Math Drills (developed by Ricky Sharp, 2011), which automatically recorded their scores so they could track scores easily. Another was an
application called Math Bingo (developed by Alan Tortolani and Dan Russell-Pinson, ABCya, n.d.) where they could earn “bingo bugs” by getting a bingo. The last application, Rocket Math (developed by Dan Russell-Pinson, n.d.) allowed them to earn “money” by answering math fact problems correctly, and they could spend what they earned on building a rocket. All three applications kept track of time. Only the Math Drills application had a tutorial feature to review the basic concepts, prompting the users to go back and redo the questions answered incorrectly. The Math Drills application also generated automatically the problems based on the facts the user had the most trouble with, adding more repetition to the problems that gave him or her the most difficulty.

Data Collection

I collected and organized data from the weekly fluency tests. I compared the scores of this year’s class with the scores of the three other past classes to identify whether there was a change in the number of students who achieved fluency by the end of the year. In addition, I compared this year’s Ohio Achievement Assessment math scores to the scores of past years to see if there were any significant differences in scores. In order to determine whether the additional time I gave the striving students effected their math fact achievement, I collected and organized the scores of the five students who received the additional iTouch intervention time and compared the math fluency rates before and after beginning the added time interventions.

Motivation and engagement are an important element of practice time. To quantify motivational aspects of math fact practice, students completed a survey, rating their perceptions of and attitudes toward mastering their math facts. The students identified the different methods they used to practice math facts and rated the methods as “fun” or “boring.” Additionally, parents filled out a survey regarding the students’ practice at home. I also kept an observation journal and noted behaviors as the students used the iTouches.

Results

Overall Class Results

Did the iTouches provide enough motivation for students to practice their math facts? Based on the results of this study, the iTouches motivated students perceived the iTouches to motivate practice time of their math facts. Student attitude surveys about different aspects of math fact practice showed positive and affirmative ratings related to the use of iTouches (Figure 1).

![Figure 1. Average student ratings of their perceptions of different aspects of math fact practice](image-url)
The average rating for students’ perceptions of their feelings when they practiced math facts on the iTouch was overwhelmingly positive. For example, question five asked, do you like to practice math facts on the iTouch? This question yielded an average of 3.9 out of a possible 4.0 points on the scale. Likewise, the majority of the students felt their fluency improved with use of the iTouches (3.7 out of 4.0), and, again, most of the students felt using the iTouches helped them learn their facts (3.6 out of 4.0). The students felt more positive about taking their math fact fluency tests as the year progressed, with the average ‘positive’ response beginning at 2.6 out of 4.0 and moving to 3.4 out of 4.0 at the end of the school year.

I also asked the students what type of practice methods they used at home and how they felt about the different methods (Figure 2). Using the iPad/iTouch had the best score (2.0 out of 2.0) related to positive feelings about the method, and using the computer had the next best score with 1.8 out of 2.0. Using flash cards scored the lowest rating for positive feelings toward the practice method or the least fun (1.1 out of 2.0). Comments from the parent survey confirmed some of the students’ responses on the survey; for example, one parent wrote, “She [my daughter] loved using the iTouches!” And another parent said, “The iTouches really motivated him to practice his facts.”

My observations from the classroom also confirmed the results of the student attitude surveys. My observation notes showed students were “totally engrossed” while using the iTouches. For example, one student continued to work on math fact practice with the iTouch even though the time for practice was over. One student exclaimed, “Ahh, can’t I keep playing?” when told that he needed to put the iTouch away. Furthermore, my notes showed none of the students working on the iTouches talked to anyone else or showed any signs of distraction. These examples represent regular observations that were made throughout the study.

There is ample evidence to maintain the iTouches provided motivation to practice math facts, but did the increased practice time or another aspect of using the iTouch result in improvement in overall math fact fluency? Based on the results of this study, math fact fluency improved during the intervention with the iTouches. I compared the overall class fluency results to classes from past years (Figure 3).

Figure 3. Percent of past years’ classes and the current year’s class achieving math fact fluency by the end of the year
For this comparison in Figure 3, I took the percentage of students who were fluent (80 out of 100 math facts correct in five minutes) at the beginning and at the end of the school year. At the beginning of the year, in all classes, 18 to 19% of students were considered fluent. At the end of the year, the three classes that did not use the iTouches reached fluent levels at an average of 66% of the class, whereas the present class reached math fact fluency at an average of 77% of total students.

The class’ Math Ohio Achievement (OAA) test results also were an improvement over past years (Table 1). In previous years, the OAA passing rate was consistently 96% whereas this year it was 100%. The class mean also improved from previous years (average of 439 to 462). Although we cannot determine whether the increased levels of fluency and achievements in the present year’s class was due to the use of the iTouches, we can speculate the use of the iTouches may have been an important method of reinforcing math fact learning. The results here support the research finding that automatic recall of math facts improves math performance (Hasselbring, 2005).

**Table 1. Average student fluency levels and percent OAA passing rate and average class scores**

<table>
<thead>
<tr>
<th>Class Year</th>
<th>% Fluency September</th>
<th>% Fluency May</th>
<th>Math OAA</th>
<th>OAA Class Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/2008</td>
<td>18%</td>
<td>68%</td>
<td>96%</td>
<td>432</td>
</tr>
<tr>
<td>2008/2009</td>
<td>18%</td>
<td>64%</td>
<td>96%</td>
<td>434</td>
</tr>
<tr>
<td>2009/2010</td>
<td>19%</td>
<td>65%</td>
<td>96%</td>
<td>452</td>
</tr>
<tr>
<td>2010/2011</td>
<td>18%</td>
<td>77%</td>
<td>100%</td>
<td>462</td>
</tr>
</tbody>
</table>

**Intervention Results for Five Striving Students**

The iTouches seemed to be an effective intervention method for striving math students. Increased practice time on the iTouches resulted in higher fluency rates for striving math students compared to their fluency rates before the intensive intervention (i.e., more time) with the iTouch applications. Figures 4 through 8 show the levels of correct scores on fluency tests for different factors of multiplication and division. The vertical black line represents the start date of the additional time with the iTouches intervention. There is considerable growth in the math fluency rates after the interventions for all five students (Table 2).
To identify the change, I tracked the change in math fluency rates (i.e., number of math facts answered in five minutes) before and after the intervention. The results are shown in Table 2. For example, after the intervention of more practice time with the iTouch, student 4 improved on the fluency tests by answering 3.4 more math facts correctly in five minutes. I also recorded how many weeks the striving students needed to move to the next level of math factors in terms of degree of difficulty. Intervention with the iTouches did make a difference in overall student achievement in math fluency rates, and, in four out of five students, decreased the amount of time it took to move up to the next level of difficulty.
Limitations

First, this study was done with a small sample size (22 students, 5 intervention students). Obviously, there needs to be additional studies with larger populations to quantify the effect of using the iTouches for learning in order to make claims about how the intervention might affect other students in other classes. Furthermore, the school is comprised of predominantly white, upper middle class students. Other studies should include different socio-economic groups as well as different types of communities (i.e. urban, rural). My students were very comfortable with technology, at least, partly, because of the access they had outside the classroom. Different results may be obtained with a group that is not as comfortable with technology.

Conclusion

The results from this study are very encouraging. Technology can be integrated into a classroom and it may be used as a tool to improve students’ math fluency. Based on the results of this study, I plan on continuing to use the iTouches for math fact fluency practice for the whole class. I will continue to search for appropriate educational applications to motivate and engage the students. I also plan on expanding the uses to other content areas, such as language arts. There is a reading application that students can use to practice and track oral fluency as well as many applications devoted to vocabulary acquisition and reading comprehension.

However, the most significant outcome of the study occurred when the iTouches were used as an intervention for striving math students. Even though it was late in the school year when I started the intervention of more practice time, the striving math students made extraordinary progress with multiplication. By starting earlier in the year, I believe

<table>
<thead>
<tr>
<th>Student</th>
<th>Before Intervention</th>
<th>After Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increase or Decrease in Fluency Rate, (Math Facts/Minute)</td>
<td>Duration of practice time before advancing to the next level</td>
</tr>
<tr>
<td>Student 4</td>
<td>-2.2</td>
<td>6 weeks</td>
</tr>
<tr>
<td>Student 6</td>
<td>-0.4</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Student 10</td>
<td>+7.8</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Student 19</td>
<td>+4.8</td>
<td>11 weeks</td>
</tr>
<tr>
<td>Student 20</td>
<td>+8.0</td>
<td>8 weeks</td>
</tr>
</tbody>
</table>

Table 2. Data related to correct math facts per minute and the time it took to reach additional levels before and after the intervention of additional time with the iTouches.
more improvement could be made with division as well. In general, the use of iTouches has great potential in helping third grade students learn math facts.

The motivational factors of using technology as well as the gaming environment of the applications seemed to have made a significant difference in the amount of time students spent reviewing multiplication and division math facts in my class this year. Students wanted to use the iTouches and were reluctant to put them away. The use of the technology added to students’ motivation to practice, and this may have contributed to the amount of time they spent practicing and/or the quality of the practice, since they seemed to be more focused on the task. This additional practice may have resulted in higher student achievement, overall, but, most importantly, suggested these devices could be powerful intervention tools for striving math students.
Works Cited


