Effectiveness of Using iPads to Build Math Fluency

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ABSTRACT

Research into integrating technology such as iPads into the curriculum for students with disabilities is still new. The purpose of this study was to examine the effect of the use of a basic math skill application on an iPad to increase basic math fluency. As part of a classwide academic intervention, the study was conducted with10 students with moderate to severe cognitive disabilities enrolled in a special education school. This four-week study employed a single-case reversal design (ABAB). Examination of data involved visual and statistical analysis techniques. Four key findings emerged. First, results indicated this intervention to have a positive effect on basic math fluency. Second, results showed that teachers perceived that the iPads had a positive impact on student engagement and interest in content. Third, qualitative data identified considerations for the integration of new technology into teaching and learning. Finally, the findings demonstrate how single-case design can be used to document the impact of evidence-based practices in special education. Findings suggest the iPad is an effective instructional tool to use in academic interventions with students with moderate to severe disabilities. Implications for practice and further research are discussed. (Contains 2 figures)

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Mobile technological devices, like the Apple iPad, are fundamentally altering the paradigm of traditional education and blurring the lines between assistive technology and instructional technology. The iPad's characteristics make it an appropriate tool for classroom instruction, including price, physical size, processor speed, storage capacity, Wi Fi connectivity, mobility, built in camera, accessibility features, and an abundance of available applications (apps). Specifically, it is the accessibility features and availability of apps that make it especially suitable for students with disabilities. For example, iPads can be used as assistive technology for students with communication disorders (Flores et al., 2012) or vision impairments (Shah, 2011). The specialized features offer opportunities for innovative instructional interventions because they easily allow the differentiation of instruction in a manner that could foster academic skills and promote independence.

Simply purchasing iPads for the classroom, however, does not guarantee effective support for student learning due to the numerous considerations for the integration of new technology into teaching and learning (Peluso, 2012). For example, how will the technology be aligned to curriculum standards? What is the capacity of the teachers to use the technology to tailor lessons to individual student needs? Will the apps provide individualized feedback to students and teachers? Further, given the financial challenges facing schools, educators want assurances that the funding for technology is targeted where it will be most efficient and effective. Thus, a well-designed strategic plan is critical for the successful implementation of technology as instructional tools. Therefore, the goal of this study was two-fold: (a) to investigate the effect of a basic math skill application on an iPad to build basic math fluency, and (b) to identify the potential advantages of and barriers to using iPads in academic interventions.

The No Child Left Behind (NCLB) Act of 2001 and the Individuals with Disabilities Education Acts (1997 and 2004) mandate that schools, districts, and states include students with disabilities in statewide assessments and show that these students make adequate yearly progress (AYP) in school. AYP is the measurement that permits the U.S. Department of Education to determine how every public school and school district is performing academically according to standardized test results. Despite these legislative mandates, most students with disabilities perform at low levels on standardized math assessments and, more precisely, demonstrate persistent difficulties with basic computation and problem-solving (Fuchs et al., 2005), requiring additional interventions to improve skills (Calhoun, Emerson, Flores, & Houchins, 2007). For instance, the National Center for Educational Statistics (2011) reported that only 4% of fourth-grade students with disabilities were performing at or above the proficient level in math.

While the technologies of teaching and learning are expanding (e.g., Promethean boards, video for introduction of concepts, using sophisticated calculators and software apps in handheld devices) in the general education curriculum, the use of such devices with students identified with developmental disabilities in these environments has not been substantially explored. In a review of 15 studies of the use of such technologies with individuals with these disabilities, disorders, and differences, it has been noted that the impact of using such iPads and other mobile devices can impact academic, communication, and transitioning skills (Kagohara et al, 2013).

Currently, many education systems are in the process of transitioning to the adoption of Common Core State Standards. These standards articulate rigorous grade-level expectations in mathematics and English language arts for all students in order to prepare for college and careers. The mathematics standards for kindergarten through grade eight are organized by domain. For example, students in kindergarten through grade five are expected to achieve mastery in whole numbers arithmetic (addition, subtraction, multiplication, and division) and to develop a strong conceptual understanding and procedural skill with fractions– critical foundations for the learning of algebra. Without effective teaching practices, however, the move too more rigorous academic content standards could bring additional learning challenges for students with disabilities. Continued use of the evidence-based instructional practices and a focus on their effective implementation may help improve access to the curriculum for all students, including those with disabilities.

Basic math fluency refers to the accuracy and speed with which a student can solve simple computations (e.g., single-digit) addition, subtraction, multiplication, and division problems (Poncy, Skinner, & O'Mara, 2006). Research shows that basic math fluency is a critical skill for students with disabilities because it is (a) a strong predictor of math achievement tests (Royer, Tronsky, Chan, Jackson, & Merchant, 1999), (b) needed to acquire higher-order math skills (Hartnedy, Mozzoni, & Fahoum, 2005), and (c) essential for future successful independent living (Patton, Cronin, Bassett, & Koppel, 1997).

Extensive research identified several effective instructional methods for improving math performance of students with disabilities (e.g., systematic and explicit instruction, self-instruction, peer tutoring, and visual representation) as summarized by the National Mathematics Advisory Panel Report (2008). Research also indicates many teachers supplement instruction with some form of technology to increase skills (Ganesh & Middleton, 2006); this is further supported by research that demonstrates technology-based interventions as an effective way to improve math ability of students with disabilities (Nordness, Haverkost, & Volberding, 2011; Ota & DuPaul, 2002). The number of technology-based math intervention studies is limited, however, and the participants in those studies were students with learning disabilities in general education settings. Additionally, limited studies focus on academics with students with severe disabilities (Nietupski, Hamre-Nietupski, Curtin, & Shrikanth, 1997). Finally, lacking in the research is the use of instructional technology for academic interventions for students with moderate to severe disabilities in special education settings.

In sum, although the literature has noted that technology can be used in the classroom in a variety of ways to improve the performance of students with moderate to severe disabilities, research has not examined the effectiveness of a single technological device, like the iPad, being used to promote academic skills. It is important to explore whether a technology device like the iPad could be an effective instructional tool to foster basic math fluency of students with moderate to severe disabilities. Therefore, this study addressed two research questions:

1. Is a basic math skill application on an iPad an effective instructional tool to increase basic math fluency of students with moderate to severe disabilities?
2. What are the potential advantages of and barriers to using iPads in academic interventions in special placement settings?

Method

Setting and Participants

The study was conducted in a classroom of a special education school in an urban district in Maryland. The school serves students in kindergarten through 8th grade with the following federal disability categories: autism, emotional disability, intellectual disability, multiple disabilities, other health impairments, specific learning disability, and traumatic brain injury. Every child has an individual education plan (IEP) and has access to integrated related services, schoolwide behavior management, and a transdisciplinary team approach to case management.

Ten 7th and 8th grade students (3 females, 7 males) with a primary diagnosis of autism spectrum disorder or multiple disabilities. The students were between 12 and 15 years of age. No students were excluded from participating in the study because the intervention was conducted with the entire class and was designed to supplement their regular classroom math instruction.

Measures

Student demographic questionnaire. Demographic data were gathered from school records on students' gender, age, ethnicity, primary disability, and IQ score.

Technology access and use. Three surveys were developed to measure the level of access and use of technology. Teachers completed two surveys. One was a survey was about their personal and professional level of access and use of technology. The other was a survey was on each student's level of access and use of technology in their classroom. Parents completed two-page survey about their child's access and use of technology in the home.

Basic math achievement. Basic math ability was assessed using the Numbers and Operations Subtest of the Brigance Comprehensive Inventory of Basic Skills II (CIBS-II; Brigance, 2010) CIBS-II is an assessment used for identifying student achievement, identifying and monitoring academic strengths and weaknesses, obtaining data to support referrals, and reporting progress for IEPs.

Basic math fluency. Basic math fluency was measured with timed math probes involving 20 addition and subtraction problems. The baseline phase used a traditional instructional approach of paper and pencil assessment. The teachers timed and scored the students' performance. The intervention phase used a basic math skill application on the iPad, the Math Racer app by i4software. The iPad app recorded the students score and time to complete 20 addition and subtraction problems.

Fidelity of intervention. Fidelity was measured by teachers' completion of a 5-item fidelity checklist to determine efficacy of treatment: providing a student with an iPad, launching the app, selecting the math skill set, monitoring the student's participation, and ensuring the student completed the activity.

Social validity. Social validity was assessed by teachers' completion of a seven question survey to assess intervention's acceptability and effectiveness for classroom instruction. Six items used a Likert-type scale (e.g., "Most teachers would find this intervention appropriate for basic math computation instruction," "I would recommend the use of this intervention to other teachers.") to indicate their level of agreement from 1 (strongly disagree) to 5 (strongly agree). The final item was an open-ended question to allow the opportunity to give feedback and recommendations for improvement.

Technology integration: Technology integration was evaluated using surveys, observation, and interviews. The purpose was to identify advantages of and barriers to integrating iPads into teaching and learning.

Experimental Design and Procedures

The four-week study employed the single-case research methodology recommended by Horner et al. (2005) and Kratochwill et al. (2010) to document evidence-based practice in special education. The ABAB design (i.e., a design with a baseline phase, followed by an intervention phase, followed by another baseline phase, followed by another intervention phase) employs within-subjects comparisons where participants act as their own control, which in turn, controls threats to internal validity. This approach allows for a systematic measurement of individual changes in performance following an intervention. That is, it allows for a more clear determination of effect. Demonstrating the effect across additional participants increases external validity and strengthens conclusions about the causal relationship (Horner et al., 2005).

The dependent variable for this study was the rate of basic math fluency gains. The independent variable was the timed math probe. A paper and pencil assessment was used during the baseline phases and an iPad app (Math Racer) was used during the intervention phases.

Several steps were completed prior to the implementation of the intervention. First, parents were informed of and gave consent for the classwide academic intervention that would be used to supplement their child's math instruction for four weeks. No parents declined to have their child participate. Next, student demographic data was collected from the school's web-based student information system. Survey data was then collected using the three technology use questionnaires.

Data were collected during the spring of 2012 for each of the four phases of the study. Participating students completed paper and pencil timed math probes for one week to determine baseline. During week two, students completed timed math probes using the iPad app. The intervention was withdrawn in week three and students continued to complete paper and pencil timed math probes for the week. During week four, the iPad app activities were reinstated and data collection continued as students completed timed math probes. Upon completion of the intervention, teachers completed social validity survey and collected basic math fluency post-test data using the CIBS-II.

Data Analysis

Timed math probes were completed and the results recorded for 3-5 sessions for four weeks. Data examination employed a combination of visual and statistical analysis techniques.

Visual analysis techniques. Data were represented graphically using time series line graph. Graphs for individual students and for the classroom were created and evaluated by visual analysis to examine both within- and between-data patterns. First, the level, trend, and variability of data within each phase were compared. Next, data patterns across the phases were examined for immediacy of the effect, overlap, and consistency of data in similar phases. In order to identify the intervention as effective, the data across all phases of the study had to document at least three demonstrations of an effect at a minimum of three different points in time (Kratochwill et al., 2010).

Statistical Analysis. Statistical analyses were also conducted to demonstrate effect of the intervention (Riley-Tillman & Burns, 2009). Dependent t-tests compared the means between two related groups on the same continuous variable (e.g., pre- and post-test scores, baseline and intervention means). Finally, binomial expansion, a nonparametric test for analysis of behavioral data that is commonly used for single-case research, determined the expected proportion of records defined as "successes." That is, the binomial test determined whether the number of data points falling on or above the baseline slope in the intervention phase were enough to be considered statistically significant.

Results

1. Is a basic math skill application on an iPad an effective instructional tool to increase basic math fluency of students with moderate to severe disabilities?

Overall, the results indicate the iPad was an effective instructional tool for students with moderate to severe disabilities. First, data from the social validity surveys and interviews show teachers were highly satisfied with the results and had perceived the intervention to be a success. For example, when asked whether the program was worth the time and effort invested, 100% responded positively, rating this question either 4 (agree) or 5 (strongly agree). Moreover, the teachers reported that the students appeared to be eager to participate with the iPad activities. Throughout the study, the teachers reported that the students showed increased interest in content during intervention phases and appeared disappointed when returning to baseline phases. Finally, teachers articulated interest in having the opportunity to continue using the iPads in the classroom.

Additional support for iPads as an effective instructional tool was found in the results from both the statistical and visual analyses. As seen in Figure 1, visual analysis showed that the students' rate of fluency gains increased during the intervention phase and regressed to baseline levels when the intervention was removed.

Examination of individual student data, however, revealed that the intervention may have not been effective for some students. A clear determination cannot be made due to the number of data points and the variability. The variability of data relates to how different or "spread out" the scores are from each other. Some students had high variability within a phase. Further, each baseline phase had three data points while the intervention phases had five data points. According to Kratochwill et al. (2010), not having at least five data points per phase and having some instances of high variability, make it a challenge to make a clear determination of effect. More data would be needed to conclude whether the intervention was effective at the student level.

Statistical analysis of data revealed three noteworthy findings. First, dependent t-test results comparing baseline and intervention means indicated a significant increase in basic math fluency. Results showed that during instruction, students were able to answer more problems correctly per minute during the iPad intervention phases ($M = 17.56$, $SD = 6.65$) than during traditional instruction phases ($M = 5.75$, $SD = 3.41$); $t(9) = -8.66$, $p < .001$.

Second, binomial test results from the classwide data indicated statistically significant differences for both the initial baseline and intervention phases ($p = .063$), and the second baseline and intervention phases ($p = .063$). That is, the proportion of successes significantly differs from chance.

Third, dependent t-tests comparing the students' pre- and post-test math performance using the CIBS-II demonstrated mixed results. Findings indicated no significant difference in accuracy, but did suggest a significant improvement in speed (as measured by seconds), as seen in Figure 2, from pre-test ($M = 1518.00$, $SD = 606.00$) to post-test ($M = 600.00$, $SD = 375.95$); $t(9) = 7.09$, $p < .001$. This discrepancy may be due to the majority of students scoring relatively high on the pre-test, leaving little room for improvement.

2. What are the potential advantages of and barriers to using iPads in academic interventions in special placement settings?

Informal observations, semi-structured interviews, and self-report surveys were used to examine this question. Several key focus areas were identified including professional development opportunities, technical and logistical considerations, and parent involvement.

Advantages. Three advantages to teaching and learning emerged from the data. First, in this study, teachers rated their perceptions of the iPad intervention as highly acceptable and effective for classroom instruction with students with moderate to severe disabilities. Second, the teachers reported that the intervention allowed the students to master or make progress toward learning goals and objectives that they had not yet been able to master using traditional instructional methods. Finally, teachers expressed that their participation in the iPad study enhanced their teaching skills and improved students' interest in the content.

Barriers. Four barriers were identified that would need to be addressed in order for the procedures for using the iPad as an instructional tool in the classroom to be more feasible. First, a high level of technical support was needed throughout the intervention, suggesting that teachers would need additional training and support in the classroom. Second, survey results indicated a vast range in the access and use of technology by teachers. Teachers who reported low technology use also reported basic ability and confidence levels to use technology. Third, findings indicated students had variety of technology available in the home but the students generally had limited use. When students did have access, parents reported that it was primarily for entertainment reasons and not for learning purposes. Survey results also indicated that students who had access to technology at home needed moderate to high assistance to use the devices. The final barrier was logistics. It took more time and effort than originally thought to oversee the use, storage, and maintenance of the iPads.

Discussion

Technology use can assist a student with disabilities in a myriad of ways, including enhancing academics, maximizing independence, participating in activities, and preparing for transition to college or employment (Burgstahler, 2003). The first purpose of this investigation was to explore how the iPad may assist students with moderate to severe disabilities in increasing basic math fluency rates. Another purpose was to identify the advantages of and barriers to using iPads to support teaching and learning. The present study enhanced our understanding of the role of technology as an instructional tool several ways.

The first contribution of this study was that it expanded current knowledge of the use of single-case design to document evidence-based practices in special education. Findings from both visual and statistical analysis techniques indicate that the iPad could be used as an effective and efficient instructional tool to foster basic math fluency of students with moderate to severe disabilities. The majority of students in this study made fluency gains. Comparison of baseline and intervention means indicated an average of a 12 point increase in the number of correct problems per minute.

Another contribution was that the results of the social validity data demonstrate teachers perceived that the iPad had a positive impact on student engagement. The findings also indicated teachers had a strong interest for expanded use of iPads in classroom instruction. Social validity data can serve an essential role in understanding, and possibly alleviating, potential obstacles in the successful adoption of evidence-based practices (Malouf & Schiller, 1995). Further, the sustainability of an intervention depends not only on how well it worked in the classroom, but also how well it is perceived by the educators who implement it (Fuchs & Fuchs, 2001). For example, teachers must perceive a classwide academic intervention as important and be able to implement it easily and effectively, if that intervention is to be sustained.

The third contribution was insight into integrating technology into the curriculum to improve student learning. The findings from this study suggest the need for the incorporation of a comprehensive professional development component. After all, teachers are more likely to use and integrate technology into their instructional practices if they receive the training on how to use technology to improve student outcomes (Rakes, Fields & Cox, 2006). However, the professional development should be tiered to the teachers' needs. Survey results indicated a vast range in the access and use of technology by teachers both for personal and professional use. One barrier to technology integration has been that training has traditionally focused on broad technical skills rather than specific uses for technology in the classroom (Hew & Brush, 2007; King-Sears & Evmenova, 2007). In the 21st century, teachers must know not only how to use technology but also when and why to use it. Therefore, professional development should include training on using iPad apps in a manner that ensures the learning objectives align with the content standards. Finally, teachers need to learn how to create well-designed and meaningful activities incorporating technology to promote student learning (King-Sears & Evmenova, 2007).

Effective technology integration into teaching and learning will require continuous collaboration among teachers, administrators, and parents in order to promote achievement. It will also require educators to be provided with the necessary training, resources, and support. Such training should be included in the initial pre-service training of teachers as well as the professional development offerings of schools and school districts.

In conclusion, research into integrating technology such as iPads into the curriculum for students with disabilities is still new. It is not known if the iPad intervention had long-term effects on the academic progress of students. For example, can the improvements in fluency be maintained over time? Follow-up data on the basic math fluency rates over an extended period of time would be beneficial to explore. Other potential contributions to the field of special education would include using iPads across the curriculum with other subjects, age ranges and settings.

Figure 1. Mean Basic Math Fluency Pates for Baseline and Intervention Phases (*n* =10)

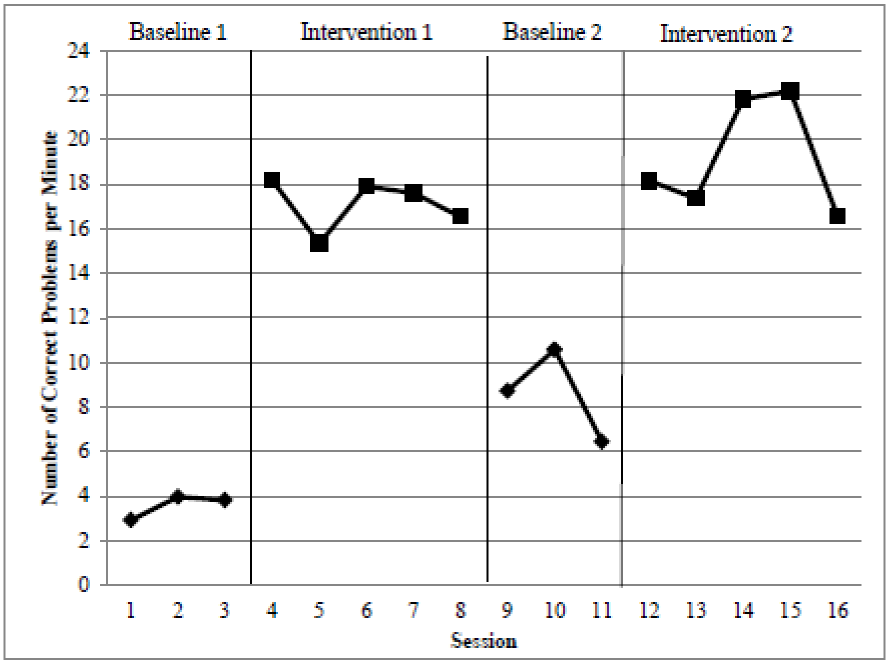
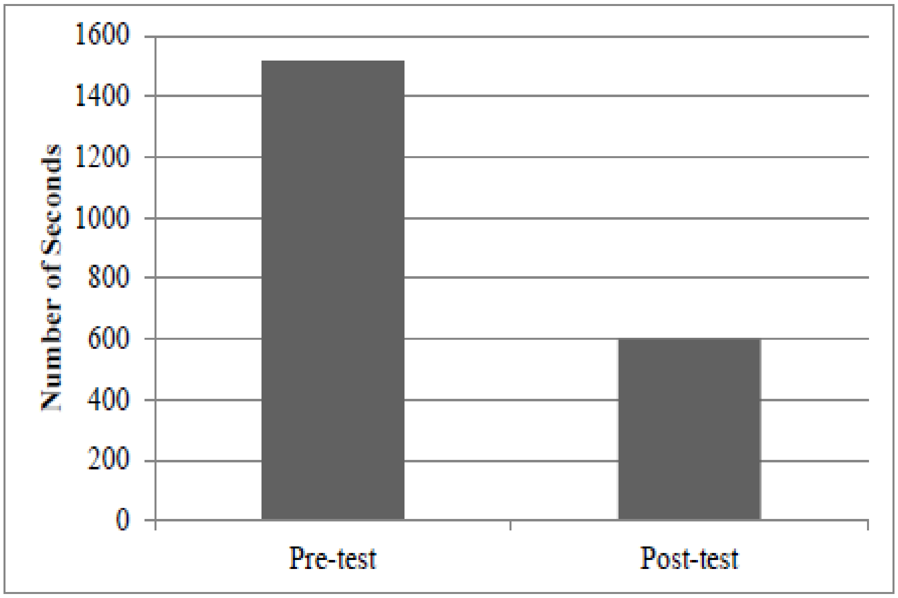


Figure 2. Mean Speed on Pre- and Post-Test of CIBS-II (*n* =10)



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