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Effectiveness of Using iPads to Increase Academic Task Completion by Students with Autism

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Abstract This single subject design study (ABAB) investigated the effects of using iPads in a classwide academic intervention to increase independent task completion and basic math skills of seven students diagnosed with autism spectrum disorders (ASD) enrolled in a special education school. The study also examined the advantages of and challenges to using iPads for classroom instruction. Traditional basic math instruction was used for the baseline phase, while a basic math skill app on an iPad was used for the intervention phase. Math probes were completed and the results recorded for four to five sessions for each of the four weeks of the study. Data on level of teacher prompting and presence of noncompliant behaviors were collected during every phase. Descriptive and visual analysis techniques were used to analyze the data. Findings expand current knowledge of the use of single subject design to document the effect of evidence-based practices in special education. Results were mixed for math skill development, but indicated an increase in independent task completion as demonstrated by a decrease in noncompliant behaviors and teacher prompt levels. Findings suggest iPads can be an effective instructional tool to enhance learning and independence. Contributions, limitations, and future research are presented.

Keywords Educational Technology, Autism, Academic Interventions, Single Case Research Design, Special Education

1. Introduction

Technology is rapidly changing how educators engage students, deliver content, and manage the traditional classroom. New technology like the Apple iPad has enormous educational implications because it makes learning portable, mobile, and accessible. The specialized features make it an appropriate tool for classroom instruction (e.g., processor speed, storage capacity, mobility, physical size, WiFi connectivity, built in camera, accessibility features) and offer opportunities for innovative instructional interventions. For example, devices like the iPads with an abundance of available applications (apps) easily supports Universal Design for Learning (UDL), a framework for making curriculum more inclusive. Although iPads have been used as assistive technology for students with communication disorders [1] and vision impairments [2], little research has explored the use of iPads as instructional tools in special education, especially for students with moderate to severe developmental disabilities [3[.Could the iPad be an effective instructional tool to promote learning and independence as part of a classwide academic intervention for students diagnosed with moderate to severe developmental disabilities enrolled in a special education school? To investigate this question, a four-week single subject design study (ABAB) was conducted with seven students diagnosed with autism.

Autism spectrum disorder (ASD) is a complex neurological disorder characterized by skill deficits in the areas of social functioning, communication, and behavior. In addition, individuals with ASD may display stereotypic and repetitive behaviors. The manifestations of the characteristics of ASD vary considerably among individuals, and within an individual child over time. Children with ASD often require direct instruction to learn key social, communication, adaptive, and cognitive skills. In addition, they generally have difficulty generalizing the use of newly acquired skills to other settings or individuals [4].

The traits of ASD can create challenges in the learning environment. The changes, distractions, and daily interaction that regularly occur in an academic setting can make it difficult for children with ASD to stay on task, which may lead to disruptive behaviors in order to avoid or escape the academic demand [5]. Problem behaviors such as physical aggression, self-injury, property destruction, and tantrums are disruptive to the learning environment and major barriers to educational development [6]. Research suggests children with ASD and related developmental disorders are likely to have academic problems in math, reading, writing, and language [7] and difficulty with independent functioning and basic math fluency [8],which are important skills for successful independent living [9, 10].

Basic math skills are critical skills because they are a strong predictor of math achievement [11]; needed to acquire higher-order math skills [8]; and essential for future successful independent living [10]. In general, however, most students with disabilities perform at low levels on standardized math assessments and demonstrate persistent difficulties with basic computation and problem-solving [12], which requires additional interventions to improve skills [13]. For example, in 2011, the National Center for Educational Statistics [14] reported that only 4% of fourth-grade students with disabilities were performing at or above the proficient level in math.

Linked to the recent changes in educational policy and law is a growing demand for instructional techniques that can promote academic skills and independence of students with moderate to severe developmental disabilities. Federal mandates such as the No Child Left Behind (NCLB) Act of 2001 and the Individuals with Disabilities Education Act (2004) require all children to participate in high stakes testing and require those scores to be used to rate school performance. The current implementation of the Common Core State Standards will set rigorous academic requirements for all students to prepare for college and careers. In order for students with disabilities to successfully participate in the general curriculum and meet high standards, their instruction must incorporate evidence-based supports and accommodations [15].

The National Mathematics Advisory Panel Report [16] identified several instructional methods that have been shown to be effective in improving math performance of students with disabilities (e.g., systematic and explicit instruction, self-instruction, peer tutoring, and visual representation). Additionally, many teachers utilize some form of technology to supplement instruction [17], which some researchers argue may increase student achievement [18].

While the use of technology for teaching and learning is rapidly expanding in the general education curriculum (e.g., interactive whiteboard systems, sophisticated calculators, software apps in handheld devices), the use of such devices with children identified with developmental disabilities has not been substantially explored [19]. Despite the limited research, the findings from analyses of research examining the use of technology with individuals with disabilities suggest technology may be an effective intervention tool [3, 19]. Kagohara and colleagues [3], for example, conducted a review of 15 studies that involved the use of technologies in education programs for individuals with developmental disabilities and found that the use of such iPads and other mobile devices can positively impact academic, communication, and transitioning skills.

Educators of children with developmental disabilities utilize a variety of approaches and methods to provide the teaching, support, and structure needed to increase children's academic performance and independence [20]. Current practices in education of children with developmental disorders generally emphasize a child-centered approach, which involves the use of prompting and positive reinforcement strategies to decrease the frequency of challenging behaviors [21, 22]. A variety of prompting procedures support the learning and development of children with ASD and related developmental disabilities, including least-to-most prompting, graduated guidance, and simultaneous prompting. In an example of a child-centered approach, the child would be provided materials and the teacher would facilitate the adoption of the target skill by prompting, supporting, scaffolding, and modeling. Positive reinforcement and feedback would be critical for teaching the target skill and increasing the likelihood of the target skill being used correctly in the future. The purpose is not only to reduce or eliminate the unwanted behavior, but also to teach children socially appropriate behavior to enhance cognitive and social skills that can be generalized to other settings [21].

The promotion of independence benefits the individual while in school and subsequently for post-secondary experiences, potentially resulting in an individual's increased autonomy and decreased dependence on others as an employee [23]. Research examining the use of devices, such as handheld prompting systems, indicates the potential to decrease one's reliance on external prompting to complete tasks [24]; however, to date, limited studies have examined how technology can be used as instructional tools to improve independent task completion. A notable exception is Mechling, Gast, and Cronin [25] who found that task completion increased for students with ASD when they could actively engage in the activity through the use of technology.

In sum, a review of the literature has suggested that technology can be used in the classroom in a variety of ways to enhance the performance of students with disabilities. What appears not to have been explored is whether a single technological device, like the iPad, can be an effective instructional tool to promote both academic skills and independence of students with moderate to severe developmental disabilities. Thus, the overarching purpose of this study was to assess the effectiveness of a classwide intervention using an iPad app to increase independent task completion and improve math performance of students with ASD enrolled in a special education school. More precisely, this study addressed the following questions:

1. Does the iPad intervention improve basic math skills?
2. Does the iPad intervention reduce noncompliant behaviors?
3. Does the iPad intervention increase independent task completion?
4. What are the advantages of and challenges to using iPads for classroom instruction?

2. Materials and Methods

2.1. Participants and Setting

The study was conducted in a classroom of a special education school in an urban district in Maryland that serves students with moderate to severe developmental disabilities.

Enrollment at the school includes 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 student has an individual education plan (IEP) and has access to integrated related services, schoolwide behavior management, and a transdisciplinary team approach to case management. In addition, at this school, students are not grouped by grade level or by disability but rather by students' academic readiness skills, communication, and social skills. The groupings are referred to as "communities."

Seven students (2 females, 5 males) with a primary diagnosis of ASD who ranged from 10 to 13 years of age participated in the study. All were diagnosed with ASD by an outside agency and exhibited moderate to severe developmental delays in communication, socialization, and behavior (i.e., functioning below 72 months of age). Each student was referred to the special education school by their local school system as to allow the student the opportunity to derive benefit from educational programming in an environment that is highly structured. The classroom was selected by school administration on the basis of students' need to improve basic math skills and the teacher's willingness to participate in the classwide academic intervention and to collect data. The classroom serves students on the severe end of the autism spectrum who struggle with behavioral challenges. Table 1 summarizes the age, gender, ethnicity, and grade level for each participant.

The classroom in this study included a teacher, an assistant teacher, and seven 1:1 aides. 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. Prior to the implementation of the intervention, parents were informed of the classwide academic intervention that would be used to supplement their child's math instruction for four weeks. All parents gave their consent to have their child participate.

Table 1. Description of participants

Participant	Age	Gender	Ethnicity	Grade Level
1	13	Male	White	7
2	12	Male	White	6
3	11	Female	White	4
4	12	Male	White	6
5	11	Male	Black or African American	5
6	11	Female	Black or African American	5
7	11	Male	White	4

2.2. Measures

Student demographic questionnaire. School records provided the demographic data on students' gender, age, ethnicity, primary disability, and grade level.

Technology access and use. Three surveys were developed to measure the level of access and use of technology. Parents completed a two-page survey about their child's access and use of technology in the home. 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.

Basic math achievement. Select items from the Cognitive Domain subtest of the Learning and Achievement Profile-3 (LAP-3) [26] were used to assess basic math skill development. The LAP-3 is a criterion-referenced assessment that provides a systematic method for observing and assessing individual skill development of children functioning in the 36-72 month age range.

Level of teacher prompts. A 6-level teacher prompting hierarchy was created to provide a systematic method of assisting students in the learning process and to assess the level of teacher prompts delivered to students during math instruction. The levels were defined: 0 = independent; 1 = minimal prompts (<25% of the task); 2 = moderate prompts (25-50% of the task); 3 = maximal prompts (>50% of the task); 4 = passive noncompliance (task not completed); and 5 = active noncompliance (task not completed and student displayed problem behaviors).

Noncompliant behaviors. A form was developed to record whether incomplete tasks were a result of a student's passive noncompliant behaviors (e.g., putting their heads down on the table and refusing to work, dropping to the ground, getting out of seat) or active noncompliant behaviors (e.g., throwing materials, demonstrating aggressive or self-injurious behaviors).

Fidelity of intervention. A 5-item fidelity checklist was developed and completed by teachers 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. Fidelity was calculated by dividing the number of steps checked by the total steps listed and multiplying by 100%.

Social validity. A seven question survey was developed and completed by teachers upon completion of the study to assess the 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. The rating form was adapted from Witt and Marten's [27] Intervention Rating Profile.

Reliability. Two scorers independently scored all seven students' assessment probes. Reliability was calculated by the following formula: agreements divided by agreements plus disagreements multiplied by 100%.

Technology integration: Surveys, observation, and interviews were used to identify advantages of and barriers to integrating iPads into teaching and learning.

2.3. Design and Procedure

This study employed the single subject research methodology recommended by Horner et al. [28] and Kratochwill et al. [29] to document evidence-based practice in special education. An ABAB design was used with four phases (i.e., initial baseline phase, followed by the introduction of the intervention, followed by withdrawal of intervention, followed by reinstatement of the intervention). The design 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 clearer determination of effect. Demonstrating the effect across additional participants increases external validity and strengthens conclusions about the causal relationship [28]. The focus of this study was to assess the effect of a classwide intervention measuring the independent task completion and math performance of students with ASD when they engaged in equivalent basic math activities using traditional instruction and an iPad app.

The number of independently completed math tasks on assessment probes, the presence of noncompliant behaviors, and the level of teacher prompting served as the dependent variables in this study. Assessment probes were completed and the results recorded for 4-5 sessions for four weeks. The intervention supplemented students' regular classroom math instruction. The design utilized traditional math instruction as the baseline phase and a basic math skill application on the iPad (Matching Game - My First Numbers app by Grasshopper Apps) as the intervention phase. During week one, students completed basic math tasks (e.g., count to 10, one-to-one correspondence, find same, match the number to the set) to establish baseline. During week two, students completed math probes that involved the students using the iPad app to learn how to recognize and understand numbers and numerals. In week three, the intervention was withdrawn and students returned to traditional math instruction for the week. During week four, the iPad app activities were reinstated and data collection continued as students completed math probes. Independent task completion data were collected during every phase. Upon completion of the intervention, teachers completed social validity survey and collected basic math fluency post-test data using the LAP-3.

2.4. Analysis

The traditional approach to the analysis of single subject research involves systematic visual comparison of data points within and across conditions of a study [29]. Therefore, in addition to descriptive analyses of data, visual analysis techniques were used. The data of the classwide baseline and intervention phases of this study were recorded using a time series graphic display 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 [29]. Finally, the improvement rate difference (IRD) score was calculated. IRD, a type of effect size for summarizing single subject research data, was used to express the difference in performance between baseline and intervention phases [30].

3. Results

3.1. Does ihe Ipad Intervention Improve Basic Math Skills?

The results suggested mixed findings. Analysis of the students' number of completed math tasks on assessment probes between baseline and intervention phases indicated no increase. The percentage of independently completed math tasks was 11.1% at baseline and increased to 14.1% during intervention. Examination of pre- and post-test scores on the LAP-3 indicated no increase in student performance; M =8.71, SD = 7.93 and M = 8.14, SD = 9.53, respectively. As presented in Figure 1, inspection of individual student data, however, demonstrated that five of the seven students maintained or showed an improvement in their raw scores on the LAP-3 over the study window.

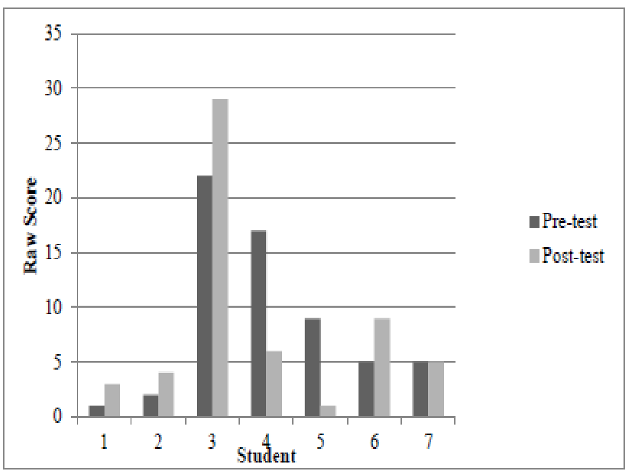


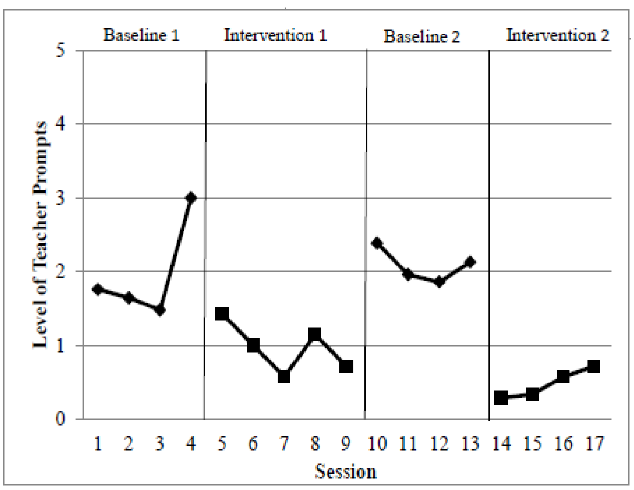
Figure 1. Individual Scores on the LAP-3 (*n* = 7)

3.2. Does the Ipad Intervention Reduce Noncompliant Behaviors?

The results were mixed. No active noncompliant behaviors were recorded during any phase of the study. There were nine incidents of passive noncompliance during the two intervention phases. Passive noncompliance decreased between the first intervention (n = 8) and second intervention phase (n = 1). Two factors may have contributed to the high number of passive noncompliant behaviors during the introduction of the intervention. One, it could be attributed to a new and unfamiliar task for the students. It could also be attributed to the students not understanding the school expectations for using an iPad (e.g., not being able to play the games they are used to playing on personal devices).

3.3. Does the Ipad Intervention Increase Independent Task Completion?

Results of visual analysis suggested moderate evidence of effect. Interscorer agreement was 98%. As shown in Figure 2, visual analysis of the classwide data indicated the level of teacher prompts decreased during the intervention phase (M = .75, SD = .65) and returned to baseline levels when the intervention was removed (M =1.97, SD = .58). Classwide, the level of teacher prompting rates were 88.9% at baseline and decreased to 85.9% during intervention. The improvement rate difference score of 100% indicated that all classwide intervention phase scores were below all baseline scores. Examination of individual student data demonstrated that 100% of the students improved their rate of independent task completion. Additional examination of individual student data, however, revealed that the intervention may have not been effective for some students. A clear determination of effect cannot be made due to the number of data points and the variability of the data. Table 2 displays the classwide teacher prompt level phase means and standard deviations. Table 3 depicts the mean teacher prompt level rates for all participants across all phases of the study.



Note: N = 7. Teacher prompts levels were: 0 = Independent; 1 = Minimal prompts (<25% of the task); 2 = Moderate prompts (25-50% of the task); 3 = Maximal prompts (>50% of the task); 4 = Passive noncompliance (task not completed); 5 = Active noncompliance (task not completed and student displayed problem behaviors)

Figure 2. Participants' Mean Teacher Prompt Level Phase Rates

Table 2. Classwide Within Phase Means and Standard Deviations of Teacher Prompt Levels (n = 7)

Baseline	Intervention	Withdrawal	Reinstatement
1.92 (.52)	.97 (.91)	2.08 (.61)	.46 (.39)

Table 3. Mean Teacher Prompt Level Rates for Baseline and Intervention Phases

Participant	Baseline	Intervention	Withdrawal	Reinstatement
1	2.50	1.40	2.93	.25
2	2.53	2.40	2.43	1
3	1.20	.40	1.25	.50
4	1.50	1.80	1.48	1
5	1.73	.60	1.73	.25
6	2.33	.20	2.53	0
7	1.69	0	2.25	.25

3.4. What Are the Advantages of and Challenges to Using Ipads for Classroom Instruction?

This question was examined using informal observations, semi-structured interviews, and self-report surveys.

Advantages. Six advantages to teaching and learning emerged from the data:

- Findings indicated a decrease in the level of teacher support and prompting over the study window.
- The iPads were easily modified to differentiate instruction for students with moderate to severe disabilities.
- Overall noncompliance declined during the classwide academic intervention. There were no active noncompliant behaviors and a decrease in passive noncompliant behaviors.
- Teachers rated their perceptions of the iPad intervention as highly acceptable and effective for classroom instruction with students with moderate to severe disabilities.
- Teachers reported that the intervention allowed the students to make progress toward learning goals and objectives that they had not yet been able to master using traditional instructional methods.
- Teachers expressed that their participation in the iPad study enhanced their teaching skills and improved students' interest in the content.

Challenges. 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.

- A high level of technical support was needed throughout the intervention, suggesting that staff would need additional training and support in the classroom if iPads were to be incorporated into instruction.
- Survey results of teachers' access and use of technology indicated a vast range. For example,

teachers who reported low technology use also reported basic ability and confidence levels to use technology.

- Results suggested that students had a 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.
- Logistical issues were evident throughout the intervention. It took more time and effort than originally thought to oversee the use, storage, and maintenance of the iPads.

In sum, the overall findings from the descriptive and visual analyses suggest the classwide academic intervention was effective.

4. Discussion

The present study explored the potential ways that new technology like iPads may be used as instructional tools to enhance teaching and learning. Technologies provide support for instruction that addresses motivation, engagement, innovative practice, and portability of application [31]. For students with disabilities, technology can assist them by enhancing academics, maximizing independence, participating in activities, and preparing for transition to post-secondary education or employment [32].

The findings from this study expand current knowledge of the use of single subject design to document evidence-based practices in special education in several ways. First, the findings suggested iPads can be effective instructional tools in classwide academic interventions for students diagnosed with ASD: (a) students demonstrated greater independent task completion when using iPads than when participating in traditional instruction; and (b) the majority of the students maintained or improved LAP-3 performance.

Second, results indicated that teachers found the intervention to be socially valid. Teachers perceived the classwide academic intervention to have a positive impact on student engagement, interest in content, and independence. Upon completion of the study, teachers reported a strong interest for expanded use of iPads in classroom instruction. According to Malouf and Schiller [33], social validity data can serve an essential role in understanding, and possibly alleviating, potential obstacles in the successful adoption of evidence-based practices. 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 [34].

Finally, the study revealed areas to consider in future technology implementation: technical and logistical considerations, staff training, and parent involvement. Research has shown that providing teachers with access to technology does not necessarily result in a high level of usage in the classroom [35]. So what might hinder a teacher's technology implementation? According to Ertmer [36], there are two types of barriers to technology integration within a school: first-order and second-order. Whereas, first-order barriers refer to the extrinsic factors (i.e., lack of resources, adequate training, technical support, and time) that obstruct technology implementation, second-order barriers refer to the intrinsic elements, including teachers' opinions and beliefs about technology, visions of technology integration, and level of confidence in using technology.

In this study, both first-order and second-order barriers were identified. Although the particular findings from this study will be used to inform instructional practices and strategic planning for the technology implementation initiative at the school where the study was conducted, the findings offer broader application. The results demonstrate that effective technology integration will require continuous collaboration among teachers, administrators, and parents in order to promote student learning.

4.1. Limitations

Despite the overall results suggesting the classwide intervention was effective, there were limitations. One limitation was that the findings may not be generalizable to the population of students diagnosed with ASD. While the ABAB research design allows the systematic and detailed analysis of individual performance, the natural setting where the study was conducted imposed several challenges. This study was conducted in the classrooms of a special education school with a high staff to student ratio. Additional studies are needed to examine the use of iPads as instructional tools with students with moderate to severe developmental disabilities.

Another limitation was an issue with the fidelity of the implementation of the intervention. Although 100% of the steps were implemented during each session of the study, teachers reported needing additional support to complete the additional tasks they were asked to do as a result of participating in the study. In addition, the intervention required extensive technological support. In a classwide academic intervention, fidelity is important at both the school level and the student level.

The final limitation was related to research design. Individual student data suggested that most students benefited from the intervention, however, some students did not. 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 [29].The determination of effect is uncertain due to the number of data points per phase and the variability of data. 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 four data points while the intervention phases had five data points. According to Kratochwill et al. [29], 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. The problem of excessive variability can be approached by seeking out and removing sources of variability or by extending the time during which observations are made [37]. More data would be needed to conclude whether the intervention was effective at the student level.

4.2. Conclusions

Apart from the limitations, the findings have educational implications. The iPads are easily modified to adapt to individual student needs. By varying the instructional and application format of math instruction, a student will be able to gain independence and familiarity with the technological device. Such independence may increase the confidence of the student as well as increase his or her willingness to engage with the device for additional of continuous practice of math skills. If the student engages with the device in a positive way, it may extend the student's willingness to use the device to support practice in other areas of study. Therefore, not only may the student be more motivated and engaged, it may serve to provide the same incentives for the teacher.

By introducing the device as a teaching tool, the teacher can expand his or her own skillset by using the device to provide additional practice opportunities for students at whatever level of skill they are demonstrating. Training for teachers, however, has traditionally focused on broad technical skills rather than specific uses for technology in the classroom [38, 39]. Given that teachers vary in their ability to utilize technology in instruction, it is likely that tiered training should be provided. Findings from this study are supported by research that suggests teachers could benefit from training to create well-designed and meaningful activities incorporating technology to promote student learning [39].

In conclusion, in spite of potential limitations, results of the study suggest that the intervention was a practical and efficient method for improving academic ability and independence of students with ASD. The findings from this study warrant future investigations into the integration of iPads into instructional activities. Future research should consider longer baseline and intervention phases; collect observational data to identify factors that may contribute to variability; and examine using iPads across the curriculum in other content areas, age ranges, and settings.

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