2015

The Use of an iPad to Support Mathematics Instruction for Students with Intellectual and Developmental Disabilities

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The Use of an iPad to Support Mathematics Instruction for Students with Intellectual and Developmental Disabilities

By

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A Thesis Submitted in Partial Fulfillment of
Requirements of the CSU Honors Program
for Honors in the degree of
Bachelor of Science in Education
in
Special Education
College of Health & Education Professions
Columbus State University

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ABSTRACT

For many years, mathematics seems to be one of the most demanding and challenging subjects for many students. Traditionally, mathematics has been taught using direct instruction with paper and pencil using a drill and practice technique. Although this form of instruction may work for some, typical students with intellectual and developmental disabilities may experience difficulties with engagement, motivation, learning, and achievement. Many schools are integrating iPads into their classrooms as a result. To explore the issue, an extensive literature review was carried out to research the use of iPads as a support in mathematics education for students with intellectual and developmental disabilities. Although there are other categories of disability that could benefit from technology as a support, the focus of discussion is students with intellectual and developmental disabilities. Studies found that using iPads generally increased student engagement, motivation, learning and overall achievement. Implications for future research include carrying out a long-term study to compare various new technology to the iPad to observe the benefits, challenges, and limitations in relation to students with intellectual and developmental disabilities.

Index words: iPad, Assistive Technology, Mathematics, Intellectual Disabilities, Developmental Disabilities, Special Education

Introduction

For many years, mathematics has continued to be one of the most important aspects of education for grades kindergarten through twelfth grade. No matter the grade level, mathematics seems to be one of the most demanding and challenging subjects for many students. According to Even and Loewenberg (2003), the gap between mathematical theory and student learning and practice is not a new concern. To address the issue of student achievement in mathematics and other academic subjects, in 2002, the No Child Left Behind Act (NCLB) as issued by President George W. Bush to support education and fuel improvement for all. In spite of the intentions of the NCLB act, research shows that students' mathematics competency continues to fall below average (Carr, 2012). Because so many students have and continue to struggle in the area of mathematics, teachers and other educational leaders are increasingly being put under pressure to improve their students' knowledge, skills, and mathematical performance on national testing (Even & Ball, 2010).

Traditionally, mathematics has been applied through the basic process of paper and pencil while the teacher gives instruction on the board (Pierce & Ball, 2009), yet children and students in today's society use technology as if it were second nature to them. Naturally, as the world of technology rapidly grows in our society, the amount of people who assimilate several types of technology into their lives will also increase. We live in a culture where people are habituated to technology, and it has begun to bring people together rather than separating them (Ludlow, 2014). As technology continues to grow, we can look forward to seeing great things happening for people of all diverse backgrounds including minority subgroups such as those with disabilities or lower socioeconomic backgrounds. For all people, technology has been integrated into our lives and our daily schedules, and it can continue to shape the environment in which it is

being used. With the impact of technology being so great, imagine how technology could be used in an educational setting for students with intellectual and developmental disabilities. Although there are other categories of disability that could benefit from technology as a support, the focus of discussion will be students with intellectual and developmental disabilities. When in an educational setting, most individuals with intellectual and developmental disabilities are allotted specific devices or technologies to address their needs and disadvantages, however, students with disabilities are most likely using the same mainstream technology and devices that most others use in their daily lives as well. Mainstream technology (i.e. laptops, tablets, and smartphones) refers to technology that is available to the general public and intended for personal use as the user sees fit. Not only could students with intellectual and developmental disabilities gain benefits from using mainstream technology in their daily lives, but they could also obtain benefits from using mainstream technology in school settings by applying the mainstream devices to their education, but with modified programs and software (Douglas, Wojcik, &Thompson, 2012).

Definitions and Terminology. For the purposes of this research, it is important to define the terms and clarify the terminology abbreviations that will be used for the remainder of the exploration. Important terms include (i) special education, (ii) technological applications (apps), (iii) iOS system, (iv) developmental disabilities, intellectual disabilities (v), and assistive technology (vi).

First, according to the Individuals with Disabilities Education Improvement Act of 2004, the term 'special education' is defined as:

> Specially designed instruction, at no cost to parents, to meet the unique needs of a child with a disability, including— ''(A) instruction conducted in the classroom, in the home, in hospitals and institutions, and in other settings; and ''(B) instruction in physical education.

Second, technological applications (ii), or apps, are defined by Castek and Beach (2013) as specialized programs that are used on mobile devices and computers that make it possible to access information for students and that mediate the connection between students and their learning goals. In other words, apps are programs that are accessed through mobile devices that allow people to extend their experiences by obtaining information provided through the program. Apps can be found on many different mobile devices such as cellphones, tablets, and computers, but the focus of this study will be on the Apple iPad that operates on the iOS system by the Apple Company.

The third definition, iOS system (iii), is an Internet operating system designed and run by Apple; it is what tells the apps and other system programs and operations what to perform ("Shop Apple", 2015). Apple devices that utilize iOS systems, often referred to as iDevices, include the many generations of the iPad, iPod, and iPhone.

Fourth, the most recent definition under the Developmental Disabilities Assistance and Bill of Rights Act of 2008 defines a developmental disability (iv) as:

> A severe, chronic disability of an individual that is attributable to a mental or physical impairment or combination of mental and physical impairments; is manifested before the individual attains age 22; is likely to continue indefinitely;

> results in substantial functional limitations in three or more of the following areas of major life activity: Self-care, Learning, Mobility, Self-direction, capacity for independent living, and Economic self-sufficiency; and reflects the individual's need for a combination and sequence of special, interdisciplinary, or generic services, individualized supports, or other forms of assistance that are of lifelong or extended duration and are individually planned and coordinated. (Developmental Disabilities Assistance and Bill of Rights Act of 2000, p. 7).

Next, under IDEIA 2004, students with an intellectual disability (v) are referred to as those with "mental retardation" which is defined as:

> Significant sub average general intellectual functioning, existing concurrently with deficits in adaptive behavior and manifested during the developmental period that adversely affects a child's education performance (IDEIA, 2004).

The term "mental retardation" was later revised under Rosa's Law to the newest term of intellectual disabilities.

Last, under IDEIA 2004, an assistive technology device is defined as:

> Any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability (IDEIA 2004).

Technology and Students with Intellectual and Developmental Disabilities. Now given the essential keywords and definitions of essential terms, it is important to understand how the concepts of technology can be put together to enhance the education of students with intellectual and developmental disabilities.

As an educator, one of the key components to teaching students with intellectual and developmental disabilities is the time and energy that is needed in order to provide supports for the students to participate in general and inclusive settings (Douglas, Wojcik, & Thompson, 2012). Teachers should focus on discovering ways for students to receive supports and embracing various technologies so that the students with intellectual and developmental disabilities may function in a general setting. In general, researchers have found that the use of technology for students in a classroom setting can lead to increased student learning, engagement, as well as mathematics achievement (as cited in Carr, 2012). Technology as a support should be embraced by teachers because it can give access to an abundance of practice for mathematics and other educational subjects that can benefit students with and without disabilities, technology as a support can increase student determination and motivation, and technology as a support can provide information derived from assessing student work including their strengths, weaknesses, and other individualized information (Douglas, Wojcik, & Thompson, 2012).

In a study conducted by Pierce and Ball (2009), mathematics teachers from an extensive range of schools were given a survey to answer questions concerning the use of technology in their classrooms. The survey was used as a means of evidence to the teachers' perceptions of technology being used in their classrooms as a positive support. In the survey of teacher perceptions towards technology in mathematics instruction, most teachers who participated in the survey agreed that technology brought students to feel more motivated, math to be more pleasing for students, a deeper understanding of the curriculum, and work to be more connected to the real-world. Each of these outcomes of technology builds upon one another. Increased enjoyment

can lead to increased motivation. Once students feel motivated to learn, a deeper understanding of the curriculum will be shaped and students will then be able to apply their knowledge to the real world. When students discover themselves actually finding pleasure in what they do at school, then learning begins to take place, especially for students with intellectual and developmental disabilities. For students with intellectual and developmental disabilities, the utilization of technology may increase motivation by providing the students with the support that they need to learn. Increased motivation then leads to increased understanding. Increased understanding then leads to making real-world connections.

The inclusion of apps in mathematics classrooms for students with intellectual and developmental disabilities is relevant to students, educators, administrators, parents, and all others who are involved in their education. With the need for improvement and the widespread availability of devices that run apps on their operating systems, there has been an influx of assistive technology and everyday technology being used in education classrooms (Ludlow, 2014). For example, teachers are finding use for tablets, smartphones, and even video game consoles such as the Nintendo Wii. Unfortunately, there is a limited amount of research in the area of apps in support of mathematics instruction for students with intellectual and developmental disabilities. The lack of research that specifically addresses technology for mathematics clearly demonstrates a need for additional exploration in order to expand on the subject of iPads as a support. However, with the use of technology increasing within schools, homes, and communities, it is relevant to explore and analyze how to incorporate various new technologies into classrooms. It is also important to research the various aspects of an iPad and

how it can be used within mathematics instruction to increase learning specifically for students with intellectual and developmental disabilities.

Technology in relation to Learners with Intellectual and Developmental Disabilities.

Ranging from general education to gifted education to special education, high-stakes expectations affect students across the entire educational spectrum. However, the students who typically experience the most challenges with education and mathematics are the students who have disabilities and who are enrolled in special education. Special education teachers are being put under pressure because of the high demands that students, specifically with intellectual and developmental disabilities, are expected to fulfill in order to have meaningful outcomes in their lifetime (Collins, Creech-Galloway, Knight, and Bausch, 2013). The pressure to improve the learning opportunities and outcomes of students with intellectual and developmental disabilities leads to the question of how can teachers improve the way in which mathematics is taught as well as how can students with intellectual and developmental disabilities obtain mathematical knowledge in a more receptive and meaningful way. One popular solution to the concerns of mathematics instruction and student outcomes is technology. The technological devices are a fundamental part of our daily lives as they act as reminders of our responsibilities, helpers to communicate with others, and informers of the things that surround us (Adams, 1999). Technology acts as many different roles in each and every one of our lives, so why not integrate technology into the realm of school education and kindergarten through twelfth grade classrooms for all students. Due to the need to increase student mathematical achievement, the central focus of exploration is how technological applications can be used to support mathematics instruction

for students with intellectual and developmental disabilities in grades kindergarten through twelfth grade.

With new technologies beginning to make an appearance in education, it is important to research which specific technologies support and/or extend student learning and mathematical competency as well as effective teaching strategies that work well with the technology being used in the classrooms (C. Attard, 2013).What follows is an analysis of the body of research related to technological apps and how they can be used to support mathematics in special education. The analysis will include studies based upon technological apps derived from iOS systems that can be used for students with intellectual and developmental disabilities in classrooms to determine the effectiveness of apps when used to support mathematics instruction designed to increase the students' overall achievement and learning outcomes.

Methodology

The method of research was an extensive literature review and investigation of previous scholarly and peer-reviewed research. The Galileo database, EBSCOhost, was used to find resources for the literature analysis, conclusions, and implications. Articles by various authors were compared and contrasted to analyze the use of technological apps to support mathematics education. Previous research methods of instruction for mathematics were also analyzed as well as the outcomes of student learning when using those methods and why it has not been beneficial to some students, specifically those with intellectual and developmental disabilities, for learning mathematics. A synthesis of the identified relevant research was carried out to form a literature review.

Research on technological apps on tablet devices such as the iPad was also explored in order to gain access to examples of apps to use in the development of my research. A search was carried out for applications for the iPad that foster academic learning that can also be aligned to state-given standards. Also, when researching iPad apps, the purposes, benefits, conflicts, and various components that make up the apps were compared with mathematics instruction that does not use technological apps on tablet devices. When discussing how to choose technological apps, there were four components as defined by Randall Palmer in *The Top 10 iPad Apps for Special Education* when reviewing apps for special education purposes. The four components include differentiation, alignment, data collection, and motivation. Palmer's four components were also compared to Aronin and Floyd's (2013) four principles for selecting apps when using an iPad for education.

Overall, the purpose of conducting research is to find relevant information that discusses the use of technological apps to support mathematics instruction with the goal to ultimately aid in increasing the learning opportunities and outcomes of learning mathematics for students with intellectual and developmental disabilities.

Literature Review and Discussion

Twenty six peer-reviewed journals and articles were researched to gain insight and information that relates to the use of iPads and technology in the classroom to improve student achievement and learning in general and special education settings. Based on the analysis of the various reviewed studies, the following thematic categories were developed: (i) legal mandates specific to assistive technology, (ii) choosing the iPad for students with intellectual and developmental disabilities, (iii) applying the iPad to mathematics instruction for students with

intellectual and developmental disabilities, (iv) how to choose apps for the iPad for use in a mathematics classroom for students with intellectual and developmental disabilities, (v) examples of effective iPad apps for students with intellectual and developmental disabilities, and (vi) possible challenges and solutions of using the iPad as a support for students with intellectual and developmental disabilities. As the literature is reviewed, implications will be discussed alongside the review.

Legal Mandates Specific to Assistive Technology

Some special education teachers are beginning to not only find use with assistive technology, but also with mainstream technology for students with disabilities in their classrooms. Although it is common to see assistive technology being used in a classroom, a great deal of mainstream technology that could be useful for teachers and students, are not readily available or mandated for education (Carr, 2012). Without being readily available and/or mandated by law, teachers may not find the time, motivation, or resources to obtain and use new, innovative, everyday technology in their classrooms. There is a law that addresses students and technology used as assistive devices, but the law has been somewhat altered to better address the needs of learners with disabilities. The reauthorization of the Individuals with Disabilities Education Act of 2004 (IDEIA 2004) included many changes for special education as well as a revision for the provisions of assistive technologies for students with disabilities. The adjustment of the law was simply that teachers must consider whether a child with a disability requires rather than needs assistive technology devices and/or services (US. C, 2008). Essentially, the replacement of the word 'requires' for the word 'needs' means that more students with disabilities are eligible to obtain access to assistive technologies in the classroom. After the 2004

reauthorization of IDEIA, any student that can demonstrate that they have a need for an assistive technology and/or service to aid in their individual achievement and learning can receive the accommodation under the reauthorization of IDEIA 2004.

With the demand for assistive technology increasing, the supply of various technologies is needed to keep up with students who demonstrate a need. Special education teachers, parents, administrators, and other school personnel have begun to look for everyday technology that will assist in meeting the diverse needs and requirements of each individual student who require assistive technology (Demski, 2009; McMahon, 2014). Technology can help to meet these students' needs by providing support where it is needed and giving students with disabilities as much an opportunity to strive and learn despite their disability. When applying the reauthorization of IDEIA 2004 and the increased demand of technology to students with intellectual and developmental disabilities specifically, according to the American Association of Intellectual and Developmental Disabilities (AAIDD), intellectual and developmental disabilities is better defined and understood as a state of functioning that calls for a need for support so that those with the disability may participate in home, school, and society just as their peers and other members of society do (as cited in Douglas et. al, 2012). The understanding of intellectual and developmental disabilities based on AAIDD aligns with the 2004 reauthorization of IDEIA because students with intellectual and developmental disabilities demonstrate a need for assistive technology so that they may function and contribute to the same extent as others. By giving students with intellectual and developmental disabilities the opportunity to use assistive devices, we are giving them an equitable opportunity to learn.

Collins, Knight, and Bausch (2013) find that equity in education means providing access to supports and services for all students in order to promote learning in mathematics rather than providing identical instruction for all students despite every student possessing their own differences. Students are different in their own unique way; so one student may not learn the same way that another one can which is why assistive technology is such as powerful tool in education. Depending on a student's level of need, assistive technology can cover an array of devices. The definition of assistive technology sanctions for a range of products that can be considered an assistive device or technology as long as it assists to improve the capabilities or limitations of a student with a disability. The benefit of assistive technology as supports is that they can work to help fill the achievement gap between students' limitations and learning (Douglas, Wojcik, & Thompson, 2012), and with an abundant of mainstream technologies becoming more readily available and integrated into our daily lives, we can begin to see the boundaries of assistive technology as supports expand. Along with the increase in availability of technology is the widespread availability of mobile devices that operate apps. Apps can be used in numerous ways to nurture mathematics instruction and student learning for K-12 students who require assistive technology or devices (Ludlow, 2014); this is where the iOS system and the iPad come into practice.

Choosing the iPad for Students with Intellectual and Developmental Disabilities

When it comes to technology that can be utilized within a classroom setting, there is a limitless amount of options that educators could choose from included assistive designed devices and mainstream devices. With there being so many options, the biggest area of concern to investigate should be, what technology works best all-around for students with intellectual and

developmental disabilities as well as the educators who teach them. Rather than exclusively searching for devices that are specifically made for students with intellectual and developmental disabilities, schools and teachers are recently choosing to integrate mainstream technology into their classrooms. According to research, the iPad is the primary choice for educational purposes in schools (Attard, 2013; Ensor, 2012; Larkin, 2014; Palmer, 2013). Since many schools are choosing to incorporate iPads into their learning environments as a supplemental aid to teaching and student learning, it is important that more in-depth research be carried out as to why and the process of how teachers and students are successfully acclimating the iPad into a mathematics classroom setting.

The Use of iPads in Education. To understand how great the impact that the Apple Company has made on the United States with the iPad, in 2011, the iPad made up for 99.8% of all of the tablets used in conjunction with twenty million iPads sold that year (Powell, 2014). With the popularity of the Apple Company and iPads, a prediction can be made that the amount of iPads sold and being used will only increase as the years go on. The most essential reasoning behind the Apple revolution in regard to education is that the iPad can be utilized as a tool for supporting as well as enriching instruction instead of using the iPad as a recreational or leisurely device (Powell, 2014). If utilized as a support tool, the iPad can be used to support instruction by acting as a supplemental device to instruction, to support students' learning, and to support an environment that is conducive to learning. Powell also found that many schools are choosing the iPad as a support because it is a computer program that is totally customizable for each student or group of students as well as its touch-controlled surface and the abundant amount of software

tools that are available. All of these components are contributing factors to why the iPad has become such a popular device in classrooms.

Applying the iPad to theory, John Dewey theorized that students learn best through individual and personal experiences by making connections between the actions that are physically done and the effect of what was done by the student (as cited in Pierce & Ball, 2009). Dewey's theory can be summarized as a student-centered approach that places value on experiences that are pertinent and flexible to the personal needs of students. The iPad allows students to learn as an individual and through experiences that they can gain by using an iPad for educational purposes at school (Carr, 2012). When using the iPad for educational purposes, the iPad has the potential to promote student-centered learning and experiences through its many features and programs on the iOS system. Experiences with an iPad are student-centered because students are more active and engaged with their participation as they use the iPad to learn individually and foster their personal needs. As previously defined, students with developmental disabilities have limitations in learning and they may need support to assist in their intellectual functioning, and students with intellectual disabilities have limitations in intellectual and cognitive functioning. The iPad could be used as a support to assist with the limitations that come with the disability in learning and cognitive functioning.

Design of the iPad for Students with Intellectual and Developmental Disabilities. When reviewing the iPad, Litterst (2015) discussed the physical look of the tablet as it applies to those with disabilities. He observed that the iPad is less intimidating and more inviting to its users because of the design of the iPad. The iPad is a small device that is significantly less overwhelming than a computer, laptop, or other assistive devices that may intimidate the user.

Not only is the iPad less intimidating, but it also more alluring than traditional educational technology. Litterst noted that the physical design of the iPad is so successful in creating desire to explore the details of the iPad that the Apple Company does not include an instruction manual when distributing their products to consumers; one can infer that the iPad is an easy-to-operate device for most users. The simplicity of the iPad is what sets it apart from other devices because it is practical enough that almost anyone could use it with ease (Palmer, 2013.) With the iPad being so user-friendly, many researchers have found that the physical features of the iPad can provide several benefits to students with disabilities. Students with intellectual and developmental disabilities typically demonstrate a need for assistance that will help them with intellectual and cognitive functioning; the iPad could work as a support that is simple and user-friendly for students with intellectual and developmental disabilities who may otherwise find using technology to be difficult.

The original iPad is a 0.34 inch thick and 1.33 pound device with a multi-touch screen that is marketed as having the capabilities of contributing to revolutionizing student learning in classrooms everywhere (Carr, 2012). According to Powell (2014), schools are choosing to use the Apple iPad in their classrooms because it is a mobile, customizable tool with a touch-controlled interface and an ample amount of software tools that are available to students, teachers, parents, and anyone who has an iPad. Powell's explanation of the iPad contains four components of the iPad: mobility, customization, touch-controlled interface, and software tools. The four features outlined by Powell are repeatedly discussed in several other articles of research by other authors as to why the iPad shows potential of being utilized in education.

Green (2002) discusses the first feature, mobility, as the "anywhere, anytime" connectivity between people and technology. In other words, mobility is the ability to easily access technology in various settings. The mobility of the iPad is ideal for mathematics instruction for students with intellectual and developmental disabilities who need individualized instruction that is flexible and adaptable for each user. By being mobile, the iPad allows students to also take the iPad to other classes so that it universal to school and to take the iPad home to share and study what was covered in class. Universal access to the iPad allows for the creation of an acclimated learning environment for students with intellectual and developmental disabilities (Rivero, 2013).

The second feature of the iPad as discussed by Powell is the adaptability of the iPad. Adaptability in terms of the iPad means that it is customizable to meet the wants and needs of the individual that is using it; this feature is perfect for students with intellectual and developmental disabilities because it allows their learning to be flexible and individualized to their specific needs. In an interview, Rivero (2013) found that adaptability also allows for the creation of a learning space that supports student engagement, creativity, collaboration, and productivity. By utilizing the iPad, students are using and increasing their cognitive and intellectual ability to interact with the iPad, the teacher, and their peers to learn. Cognitive ability and intellectual ability are what characterize students with intellectual and developmental disabilities, so their cognitive and intellectual abilities could be accommodated by benefiting from using the iPad.

The third feature of the iPad as outlined by Powell is the touch-controlled interface. The interface is the screen that controls all of the functions on the iPad; this feature is relevant to students with intellectual and developmental disabilities because it contributes to the user-

friendly idea of the iPad. Students with intellectual and developmental disabilities may not have the ability or skill to type on a QWERTY keyboard or a mouse, but with the iPad, those skills are not necessary (Litterst, 2015). Students can more easily distribute and control their work using the iPad as a supporting device. The touch-controlled surface is such an important feature because it makes available the experiences that were discussed previously as Dewey's theory of learning through experiences. By experiencing education through the touch-controlled interface, the students are relating their new learned knowledge through their body and their mind. Many previous researchers have linked touch with learning. Although written at an earlier time, the Phenomenology of Perception by Merleau-Ponty discusses the relationship between experiences done through the physical body and the objects that one has used during the experience. Piaget's (1952) theory of sensory-motor processes places importance on experiences through touch in relation to perceptual learning. Other researchers place notice on the fact that many teachers simply use touch to draw their students' attention to focus on what they are teaching (Flewitt, Kucirkova, & Messer, 2014). Also to mention Gardner's (1983) theory of multiple intelligences and learning styles finds that touch fits the learning style of kinesthetic and tactile learners. Drawing from these theories of research, we can derive that using touch when learning stimulates student engagement by creating memorable experiences that students can learn from. Overall, all of these theories contribute to the idea that touch facilitates learning which is why the touch-controlled interface of the iPad is an important feature of the iPad.

Lastly, and one of the most important elements of iOS systems and the iPad, is the copious amount of software tools that are available through the iPad. The iPad consist of a plethora of software tools and features that can be integrated into educational settings such as

special education classrooms. The best source of information on the various features and software tools was the Apple website. The Apple (2015) iOS system includes a variety of accessibility features that can help people with disabilities experience more of what the iPad is made to offer its consumers. The built-in voiceover screen reader allows those who are blind or have low vision to hear a description of the item that is being touched on the screen. The screen reader could also be used specifically for students with intellectual and developmental disabilities who may struggle with reading because of their cognitive limitations. With Guided Access, another feature on the iPad, teachers can restrict an iOS device to one app at a time, and even limit the amount of time spent in an app which can be helpful to students with intellectual and developmental disabilities so that they can manage the iPad more easily without getting confused on all of the running apps that could be left in use in the background. Another software feature that is programmed on the iPad is called Switch Control. Switch Control gives individuals with limited physical or motor skills complete control of their device through switch access. Switch access is a control that allows you to select everything you need to access using one switch. A few options for a switch could be an external adaptive switch, the installed camera that will detect motion to trigger the switch for users who have difficulties with motor skills. The iOS also offers many other beneficial accessibility features, such as dynamic screen magnification, playback of closed-captioned video, braille displays, mono audio, simplified screen gestures, and many more. Students with intellectual and developmental disabilities could also face any other possible challenges (i.e. motor deficits, hearing impairments, etc.) that could be solved by many of the features designed by Apple that are all accessible through the iPad.

When using the iPad, any of the accessibility features can be turned on or off based on each individual student's needs.

Statistics. Another reason that schools and educators may be choosing the iPad is that students, teachers, parents, and other important contributors to education are already familiar with Apple products such as the iPhone and the iPad (Asher-Schapiro, 2013 & Siegel, 2013). When filing the 2015 annual Apple report for each quarter, the CEO of Apple, Tim Cook, stated that the revenue for Apple products grew to $74.6 billion in revenue which is a 30% increase just from the previous year 2014 (Apple, 2015). Familiarity of the iPad for students with intellectual and developmental disabilities can work in their favor; if using another tablet or mobile devices that students with intellectual and developmental disabilities are not familiar with, a limitation would be having to take time to teach a new skill (Douglas, Wojcik, Thompson, 2012). By using the iPad, teachers can focus their time and efforts on creating meaningful opportunities for students with intellectual and developmental disabilities to contribute in inclusive settings by using the supports such as the iPad that will cater to each student's individual needs.

In comparison to other technologies such as computers laptops, iPads offer familiarity, universal access, mobility, ease of access, and flexible learning opportunities for students which in return gives the students the opportunity to develop their own creative work instead of merely being receptive of work from others such as reading textbooks or articles from the internet. With an iPad, students can still be afforded the opportunity to be receptive of the work of others (Ensor, 2013), but the iPad will also give the students opportunities to use that information that they absorbed to recreate, display, calculate, project information, etc. (Attard, 2013); the possibilities are virtually endless.

Applying the iPad to Mathematics Instruction for Students with Intellectual and Developmental Disabilities

Along with the many reasons that the iPad has dominated the field of education are the applied benefits that the iPad can bring into a mathematics classroom with students with intellectual and developmental disabilities. Before technology was integrated into classrooms for students with disabilities, teachers taught mathematics using drill and practice strategies and students took notes using pen and pencil (McMahon, 2014, Pierce & Ball, 2009). However, students with intellectual and developmental disabilities may not benefit from drill and practice as a teaching strategy. Students with intellectual and developmental disabilities may not find learning the traditional way to be meaningful due to the mundane nature of the instruction (Carr, 2012). Instead, students with intellectual and developmental disabilities could use the iPad to engage them into learning mathematics.

When using iPads with mathematics, previous research indicates that many teachers were heavily relying on the mathematics apps provided on the iPad to take the place of traditional mathematics worksheets and practice in a textbook (Attard, 2013). The iPad can indeed be used as an updated version of worksheet or practice problems from a textbook, but the iPad is capable of much more than a repetitive, practice and drill worksheet substitute. The iPad has been selected by many schools because of the abundance of accessibility features that supports individual needs and provides flexibility, the availability of countless apps that are continuing to be developed, and the popularity and familiarity of the product itself that saves time and effort (McMahon, 2014). Rather than using the iPad as a practice and drill technique, teachers should

utilize the iPad as a means of differentiating instruction, promoting individual learning, and collaboration with others (Ensor, 2012).

Teachers can use the iPad alongside pedagogical instruction to integrate it into mathematics (Attard & Northcote, 2011). When used with instruction as opposed to a replacement of instruction or supplemental worksheets, it can lead to self-directed learning, personalized learning, an extension of learning, and increased engagement (Ellis, 2011).

Self-directed Learning. Self-directed learning refers to a 1 to 1 ratio of the student with the iPad. As a teacher with many students in their classroom at a time, it can be difficult to monitor and meet the unique needs of each and every individual (Ellis, 2011). Conversely, with the iPad, students are afforded the ability to self-direct their learning with the iPad through apps and features that can be utilized during mathematics instruction or during student cooperation time. Students can continue to learn while the teacher assists other students and can move at their own pace as they direct themselves to the learning objective using their iPad.

Another option that the iPad affords is a ratio of multiple students to one iPad. By utilizing the iPad with multiple students with one iPad, the iPad is being used in small groups or with partners depending on the instruction and the students' needs. Working in groups or pairs, students can use self-direction to share their work, opinions, and knowledge to contribute to solving problems given using the iPad (Ensor, 2012).

Personalized Learning. The iPad can also allow mathematics instruction to be personalized to meet the individual needs of each student with an iPad. The iPad is a device that allows flexibility and differentiation of settings and features while still performing the designated skills and tasks that other students are doing. Mathematics instruction can also be personalized

with the iPad by using different apps and different features on the iPad that were previously discussed and outlined as features of the iPad.

Extension of Learning. The iPad promotes an extension of learning through the mobility of the device. Students are able to extend mathematics beyond the classroom by reviewing lessons saved on the iPad, playing game-based learning apps during down time, and extending their learning to family and friends as they share their knowledge and achievements that are stored on the iPad. The accessibility provides students with intellectual and developmental disabilities the accommodation and modifications that they need to bridge the gap between their disability and learning. The accessibility features on the iPad can be supplemental supports with mathematics instruction so that each students receives the flexibility and support that they need while the teacher makes their way around the class.

Increased Engagement. Lastly, mathematics instruction can pair with the iPad by assigning a more active role for students during instruction and working time. Ellis (2011) states that public schools has seen 50 to 60 percent increases in their achievement for math as well as other school subjects when the iPad was implemented in the classroom. By giving students more active roles with using their iPads to learn, achievement in mathematics is increasing and leading to student engagement and learning.

Overall, applying the iPad to mathematics allows students to learn, engage, participate, and collaborate with peers, teachers, and others through manipulation of the iPad.

How to Choose Apps for the iPad for Use in a Mathematics Classroom for Students with Intellectual and Developmental Disabilities

After choosing to integrate the iPad into classrooms, it is important to take time to choose which apps the students will utilize when using the iPad for mathematics support. There are numerous apps that are mathematically based available for students and teachers can use to support students' needs (Attard & Northcote, 2011), however, not all of the apps that are made for the iPad are appropriate in regard to the curriculum or the standards given by each state. Special education teachers are encouraged to teach using evidence-based practices that align with the CCGPS standards as well as providing instruction for functional skills for the students (Creech-Galloway, Knight, & Bausch, 2013). Taking time to look for apps using resources can be time consuming and difficult for teachers who do not know what to look for when choosing apps.

As a solution to the potential issues of searching for relevant apps, Mautone (2013) designed a rubric for teachers to use when choosing apps that will align with standards and provide for students with disabilities. The rubric is the App Selection Rubric (ASR), and it helps to get rid of confusion and eliminate apps when looking into the thousands of apps that are provided for the iPad. The five areas of the rubric are the developers' knowledge of the disability (intellectual and developmental disabilities in this case), ratings given by the users, ease of use, cost of the apps, and functionality of the apps.

In regard to the five areas of the ASR rubric, ratings given by the users refers to the evaluations and reviews that a user gave the app. By looking at user ratings, teachers could gain first-hand insight from someone who has used the app themselves. The Apple store uses a scale

of one through five stars with five being the highest rating. The Apple store also allows users who have downloaded and/or purchased an app to leave personal comments based on their experiences with using the specific app. Second, ease of use refers to how easily someone could use the app. Ease of use is especially important when using an iPad for students with intellectual and developmental disabilities due to cognitive impairments that would typically affect their performance. Third on the ASR rubric is the cost of apps. Cost of apps refers to the amount of money that has to be paid in order to access the app. There are many apps for the iPad that are free for all users, but there are also some apps that may have a specific cost. Teachers who may not have funding specifically permitted for purchasing apps on the iPad should consider the cost. Fortunately there are plenty, thousands even, of apps that have no cost. Last, functionality of an app refers to what the app actually does or the purpose. Because there are plenty of apps available, functionality of an app is very important. When choosing apps, teachers should consider how the app is supposed to function as a part of the lesson. The functionality of the app should always be relevant to curriculum and aligned with standards so that each student will be supported with apps that help them learn.

Overall, the areas of credentials on the ASR rubric of choosing apps will help to reduce the options for choosing apps and narrow the choice down to apps that are helpful in the classroom for teachers and students with intellectual and developmental disabilities.

Aronin and Floyd's Principle for Choosing Apps. Additional research on choosing iPad apps was conducted by researchers Aronin and Floyd and Powell. Aronin and Floyd (2013) outlined four principles that can be used to choose appropriate apps for students to support mathematics instruction. The principles include student-sourced outcomes, cause and effect

relationships, observable outcomes, and readily available feedback. The first principle of Aronin and Floyd is that students should be the source of action when making outcomes. Students with intellectual and developmental disabilities need to be actively engaged and participating in their learning to make memorable and meaningful experiences. The iPad offers engagement and physical action by allocating for each student to use individually use the iPad to learn. The second principle is that students should be able to see cause and effect relationships when changing their actions from the beginning and how it affected the end outcomes. The third principle is the outcomes should be observable to the teacher as well as the student. When looking at results of actions, it is important to be able to observe student work and growth so that each party can monitor the learning and achievement being done when using the iPad. Last, the fourth principle is that the action and reaction should be available immediately for students to see so that they can make connections between the cause and effect; this principle correlates with the second principle of choosing appropriate apps. With an iPad, immediate feedback can be available on demand of each student (Ensor, 2013). When using these principles to choose apps, the iPad has the potential of being a learning device that warrants many opportunities to learn in a flexible manner that caters to needs, learning styles, and preferences.

Palmer's Principles for Choosing Apps. In comparison to Aronin and Floyd's principles for choosing apps, there are four components that are defined by Palmer when reviewing apps specifically for special education purposes (Palmer, 2013). The four components include differentiation, alignment, data collection, and motivation. Palmer's principles are premised from the idea of tracking learning while providing the student with feedback and learning outcomes for students with disabilities.

The first principle as outlined by Palmer is differentiation. Apps used on the iPad should allow instruction to be differentiated for each individual student in order to serve their abilities and their Individualized Education Plan (IEP). McMahon (2014) agrees with the notion of differentiation. McMahon conducted research using the instructional framework called Universal Design for Learning (UDL) to show how the iPad could be utilized for students with disabilities as a supporting tool within the classroom. As outlined by McMahon, the UDL approach to education places emphasis on differentiating instruction through multiple means of representation, expression, and engagement. Multiple means of representation applied to an iPad means that students can use the iPad to have instruction provided to them in multiple ways such as visuals, audios, and the use of touch when using the iPad. Multiple means of expression means that the student can take the information that was given and distribute their own thoughts and work however way appropriate for their specific needs. The iPad has many features that can be used for students with disabilities to create their own work in many forms. Multiple means of engagement means multiple activities that engage the student into learning. Students can use multiple means of engagement with an iPad if given many options to different apps or programs that can be utilized that lead to the same acquisition of knowledge as the other options for engagement.

The second principle outlined by Palmer states that apps should be able to be aligned with the performance standards provided by the state. Aligned with standards means that curriculum and materials correlate to the requirements that students must learn to follow with the national-norm. The third principle, data collection, infers that iPad apps should be able to be used to collect data that demonstrates student learning and record progress of students' activity when

using the app or the iPad. Data collection aligns with Aronin and Floyd's principles for choosing apps. Data collection can be used to provide feedback to the student so that they may self-monitor and progress with using the iPad as a support for their disabilities. Lastly, apps should be used as a motivational tool for students' with intellectual and developmental disabilities and should promote students' achievement and self-determination. Without motivation, students with intellectual and developmental disabilities will not perform tasks using the iPad and student achievement could likely decrease due to lessened student engagement.

Teachers choosing apps to operate on iPads for students with intellectual and developmental disabilities must take a lot into consideration, but with there being so many apps that have been developed, teachers have more options and choices that could be used to engage students with intellectual and developmental disabilities to increase their intellectual and cognitive abilities and improve student achievement (McMahon, 2014). Although having many options can be a benefit, narrowing down the options can make choosing apps difficult for teachers. Choosing apps can become an easy task by applying the principles of Aronin and Floyd and Palmer. Also, by using a rubric for choosing apps, teachers should be able to eliminate and choose apps that provide flexible and appropriate options and learning opportunities for students with intellectual and developmental disabilities.

Examples of Effective iPad Apps for Students with Intellectual and Developmental Disabilities

After using Palmer's four principles (differentiation, alignment, data collection, and motivation) for choosing apps, examples of effective iPad apps were chosen form the available apps from the Apple store. A few specific examples of apps that work effectively with students with intellectual and developmental disabilities include SymbolSupport, iReward, and the Apple

iWork trio. Research was done using the previously listed apps and described using the four principles of Aronin and Floyd for choosing apps which are functionality, user ratings, ease of access, and cost.

The SymbolSupport app is a program available on the iPad that can work as an assistive support for students with intellectual and developmental disabilities. The functionality of the app automatically translates words into pictures and symbols which is a skill that students who have cognitive impairments typically struggle with. Cognitive impairments are typical characteristics of students with intellectual and developmental disabilities. SymbolSupport could also be very useful for students with intellectual and developmental disabilities in a mathematics class due to the symbols and pictures that are involved in mathematics curriculum. In regard to ratings, the SymbolSupport app received four stars based on users that have used, evaluated, and assessed the app. The app is also recommended for all age levels. According to the Apple Store, the current cost for SymbolSupport is $39.99, but the developer of the app offers a free SymbolSupport Viewer app that will allow the user ease of access by receiving, reading, storing, and printing documents that are created in the full version of the app (Palmer, 2013).

The iReward app can act as a motivational support for students with intellectual and developmental disabilities. The iReward app was specifically selected by the Apple Company as an app for special education. The functionality of the app is to keep an earning chart for individual students or a group of students that monitors student behavior and rewards. The app provides a visual for students' progress towards a specific goal which makes the ease of access better for students with intellectual and developmental disabilities who may have trouble with processing information in mathematics. Students with intellectual and developmental disabilities

could use the iReward app in mathematics to practice math skills such as counting their earned rewards and the frequency of their behaviors. By doing so, the iReward app is also being used as a support for students to self-monitor and self-direct their behavior which is a skill that students with intellectual and developmental disabilities typically struggle with. The current cost of the iReward app is $2.99 with a 3 and a half star user rating.

The Apple iWork trio is an app that consists of three components that users may find useful when performing general productivity of work and information (Siegle, 2013). The three components of the app are *Pages, Numbers,* and *Keynote. Pages* is a word processing app that allows students with intellectual and developmental disabilities to use a word document in a more accessible way. The app is flexible to its user and allows ease of access to adding, moving, resizing, and rotating objects in a fluid manner so that students are not stuck trying to put their thoughts in a word document. *Numbers* is an app that makes organizing numbers less complex and simpler for students with intellectual and developmental disabilities. Numbers can be used to organize numbers, functions, tables, and formulas which is great for students with intellectual and developmental disabilities who may struggle with organizing mathematics problems. Numbers can do the organizing while students with intellectual and developmental disabilities input the numbers. *Keynote* is an app that can help students with intellectual and developmental disabilities create presentations for mathematics when they might otherwise struggle to do so. Using Keynote, students can easily access their presentation by displaying the work they created on their personal iPad on any browser or through a program that allows students to display their work through a wireless Bluetooth connection. Cost-wise, the Apple iWork bundle is constantly being upgraded and is available for free on an iPad when using an internet browser.

The apps SymbolSupport, iReward, and the Appple iWork are three examples of effective apps for students with intellectual and developmental disabilities. Overall, effective apps allow flexibility, ease of access, and can easily be integrated into a classroom as a means of differentiation, alignment, data collection, and motivation for students with intellectual and developmental disabilities.

Possible Challenges and Solutions of Using the iPad as a Support for Students with Intellectual and Developmental Disabilities

Although the iPad offers many benefits, there are also possible challenges that could take place when implementing the iPad into a classroom setting. Those who oppose the use of iPads as instructional tools in education would probably advocate for the challenges that iPads may bring to the classroom. A few possible challenges could include app selection, security, financial barriers, and utilization management of the iPad when being used in a classroom setting.

Selecting Apps. The iPad has millions of apps that are created every single day by app developers. As stated in the Apple (2015) release report, a cumulative $25 billion was earned by app store developers alone. In 2014, the newest iOS system was introduced. The system update, iOS 8, gave app developers the ability to generate new apps and offer more innovative features; this could be both a benefit as well as a challenge for educators looking to integrate the iPad into their classrooms. With there being so many options for apps to choose from, teachers may find that they do not have the time to go through and select appropriate apps that correspond to their lessons as well as the standards aligned by the state.

Financial Barriers. Teachers may also face challenges and concerns for students who are from a lower-socioeconomic background (Pierce & Ball, 2009). It is true that the newer

generations, or yearly models, of the iPad are more expensive; however, if the newer generations are too expensive for students, Apple provides options of different iPads. For example, those students from a lower socioeconomic environment may not be able to afford the newest iPad. Each generation of the iPad, beginning with the very first generation of the iPad ranging all the way to the newest generation of the iPad Air 2, has many apps and tools that can serve the purpose of supporting mathematics instruction for students. The Apple Company also offers choices of various generations of the iPad which could assist with the financial barriers of the iPad for education. Despite the age of the older generations of the iPad, each generation can be used to operate the same apps and programs as long as the iOS system remains up to date with the system updates which are available to every Apple user. The newer iPads are more advanced in their abilities and functions, but students who may need the more advanced or possibly the less advanced generations of the iPad for user accessibility options can be given that specific option to fit their needs. Apple also offers education institution discounts for K-12 schools who may want to purchase classroom sets so that students do not have to worry about supplying an iPad while at school (Apple, 2015).

Security. If schools are taking advantage of the education institution discount offered by Apple, a challenge or concern of security could arise. Security issues with an iPad could include a student misplacing an iPad, an iPad getting stolen from a student by whomever, or students trading iPads that may have had confidential information about the specific student to who it was assigned. A solution to the security concern could be the Find My iPhone feature. With the Find My iPhone app, iPads that become lost or stolen can be tracked, locked, and security wiped if needed (Ellis, 2010). The Find My iPhone app also works if students were to bring their own

personal iPads to school. Once tracked, the iPad can be returned to the school or its rightful owner, and the solution is resolved.

Off Task Utilization. Other possible challenges could include students utilizing the iPad for activities not related to educational tasks. Students with intellectual and developmental disabilities could possibly become distracted from and lose engagement in the assignment, if tempted by many apps available on the iPad. One possible solution to the issue of off-task utilization could be eradicated if the teacher sets proper guidelines and monitors the students to foster learning and stay on track. Students with intellectual and developmental disabilities are commonly characterized with impaired cognition, so setting simple guidelines would be very important in not only monitoring behavior when using iPads, but it can also help those students who may struggle with using the iPad. Another possible solution to improper utilization of the iPad during instruction could be the guided access feature of the iPad. Guided access allows teachers to control how many apps are being used on the students' iPads as well as how much time they are allotted in the app. Students who are off-task can be redirected without demonstrating punitive solutions using guided access.

Although some challenges may arise with using the iPad in the classroom, a solution can be executed to solve the problem to work out the issues that could get in the way of student learning and achievement. The challenges of the iPad are complications in the process of implementing the device into a classroom setting, but the features of the iPad make the challenges more obsolete.

Conclusions and Implications for Future Research

In education, research finds that mathematics has been a continuous struggle for many students with and without disabilities. Special education teachers are put under pressure for those students with disabilities to improve their abilities and learn to state and/or national standards. Students with intellectual and developmental disabilities, however, are characterized as having difficulties with their cognitive abilities and skills. Despite the disabilities of students and learners, the pressure to improve the learning opportunities and outcomes of students with intellectual and developmental disabilities leads to the question of how can teachers improve the way in which mathematics is taught as well as how can students with intellectual and developmental disabilities obtain mathematical knowledge in a more receptive and meaningful way. Many teachers and schools have considered technology as the answer to increasing their student achievement and learning outcomes because students with intellectual and developmental disabilities demonstrate a need for supports that will assist in cultivating their intellectual and developmental skills and abilities.

The iPad is a popular mainstream device that schools have adopted into their environment to facilitate and support their students with and without disabilities. The iPad is an option for teachers to integrate into their classrooms for students with intellectual and developmental disabilities. The device has an array of available features that provide accessibility to students with intellectual and developmental disabilities so that they may succeed and learn at an equitable rate as their peers without disabilities. When placing the iPad in educational settings, it should be used as a support to students as well as instruction. Students should be able to utilize the iPad in various settings to create, be engaged, and participate in

activities that they may have otherwise needed assistance from another person. Teachers should be able to use the iPad as a support when implementing pedagogical instruction that does not allow the iPad to replace the actual teaching.

When implementing iPads into instruction, teachers should consider guidelines and strategies provided by research and theory. Guidelines for the application of iPads in the classroom with students who have intellectual and developmental disabilities allow the benefits of the iPad to be in full effect. Teachers should also consider taking time to carefully select apps for students with intellectual and developmental disabilities. Apps should be engaging, increase student motivation, be aligned with standards, and allow differentiation and flexibility to meet the needs of each individual student. If not, teachers may create a risk of a decrease in student achievement and engagement.

There are challenges that could arise when utilizing iPads and technology into education, but with guidelines, strategies, and appropriate implementation, the iPad should work as a support to benefit students with intellectual and developmental disabilities and allow creation, collaboration, and a meaningful, student-learning experience.

Implications for Future Research. After reviewing twenty six peer-reviewed journals and articles, I have come to the conclusion that more research needs to be conducted in the area of applying the use of an iPad specifically for the subject of mathematics as well as for students with intellectual and developmental disabilities. In order to further studies of the use of iPads as supports for mathematics instruction for students with intellectual and developmental disabilities, researchers could administer a long-term study of the effects on student motivation, engagement, achievement, and ability to perform designated task.

Researchers should also consider completing a study with students with intellectual and developmental disabilities using other mainstream technology such as Windows Tablets, Nooks, or Samsung Tablets including the most chosen iPad. By doing a study including other devices, researchers can compare the findings of benefits, challenges, and limitations of each for students with intellectual and developmental disabilities when learning mathematics. Future researchers should also consider a cross-curriculum study to explore the use of mainstream technology in other subjects. A cross-curriculum study could go into further study for students with intellectual and developmental disabilities in the development of adaptive skills needed to experience meaningful and desirable outcomes for living a successful life.

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