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Research Article

Determining Studies Conducted upon Individuals with Autism Spectrum Disorder Using High-Tech Devices*

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Abstract

This study explores 67 experimental research articles written about children with Autism Spectrum Disorder using high-tech devices. The studies in this research were accessed through EBSCO, Academic Search Complete, ERIC, and Uludağ University online search engines using keywords such as *autism and technology*, *autism and computer*, *autism and tablet*, and *autism and portable devices*. The studies have been categorized based on their scope: studies conducted using computers and studies conducted using smart portable devices. The software programs used in these studies are described in a separate table. Research findings indicate that studies conducted on children with ASD using high-tech devices found them to be effective for teaching academic skills, communication skills, and social-emotional skills.

Keywords

Autism spectrum disorders • High technology • Review • Research

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Autism spectrum disorder (ASD) is a complex developmental disability observable within the first three years of life. Furthermore, ASD is a progressive disability that affects socialization, language, communication, and other activities and interests throughout the person's life. The degree of response to the disorder differs from one individual to another. In 2013, the name of this disorder group was changed to Autism Spectrum Disorder in the DSM-V diagnostic criteria and was divided into categories based on individuals' degree of response to the disorder (Heward, 2013; Xin & Sutman, 2011). The most significant characteristics of individuals diagnosed with ASD are their problems in social interactions and communications. In addition, their social contact with peers, understanding and expressing emotions, and establishing eye contact are also problematic (Heward, 2013).

Beginning to teach children with ASD at an early age using effective applications plays an important role in minimizing their life-long disabilities. Educational programs that are specially designed and individualized based on their learning abilities should be among the most effective instructional methods implemented. Today, the number of studies on the use of technology in educating children with ASD has increased, and the results of these studies demonstrate that children with ASD learn better using technological devices (Basil & Reyes, 2003; Bosseler & Massaro, 2003; Clark & Green, 2004; Coleman-Martin, Heller, Cihak, & Irvine, 2005; Delano, 2007; Moore & Calvert, 2000).

Cohen (1996) mentioned the significance of visual aid systems for educating children with ASD and stressed that they learn by seeing rather than hearing (Bölte, Golan, & Zwaigenbaum, 2010; Coleman-Martin et al., 2005; Rao & Gagie, 2006). Technology-supported educational applications can be scrutinized into three categories in terms of educating children with ASD: (a) applications that utilize low-level technology; (b) applications that utilize medium-level technology; and (c) applications that utilize high-level technology (Michael, 2004).

Applications that utilize low-level technology are those that peruse visuals with pictures. Activity schedules, calendars, and picture charts in particular can be considered in this group. Applications in this group do not require the use of an electric-powered device. The Picture Exchange Communication System (PECS) and social stories developed by Gray (1993) are examples of applications in this group (Dettmer et al., 2000; McClannahan & Krantz, 1999; Michel, 2004).

Applications that utilize medium-level technology are conducted with the help of simple devices. These applications can be implemented using tape recorders or other recording devices. Timers used in teaching children with autism can be given as another example of this. These devices are generally used with visual and textual cues (Michel, 2004).

High-tech applications present high costs. Technological devices such as desktop computers, notebooks, smart phones, video cameras, software, and scanners could be considered in this group. The number of high-tech applications in the training of children with autism increases every day. Study results demonstrate that high-tech use improves the attention span of children with autism, decreases their behavioral problems, and facilitates their achievement in leisure and game skills (Dauphin, Kinney, & Stromer, 2004). A literature review of the studies conducted using high technologies is considered helpful for researchers in the field both nationally and internationally. Furthermore, researchers are assumed to be able to access the software mentioned in this study, as well as benefit from the knowledge base that has been created.

Purpose

The purpose of this study is to review studies conducted over children with ASD using high technologies.

Method

Research Design

The findings of this study were analyzed using document analysis, a qualitative research method. The data sources are studies gathered under the objective of this study (Yıldırım & Şimşek, 2013), which scrutinized transcripts on high-tech instruments utilized for teaching children with autism.

Identifying Studies

Certain criteria were set up for accepting studies into the research. These were the studies must have (a) been published between 1995 and 2015 in a peer-reviewed journal, (b) been conducted over children with ASD, (c) been conducted using experimental or quasi-experimental methods, and (d) used high technology. Furthermore, studies conducted using video-model applications were excluded from the study because separate literature review studies have been done on these models, even though video-model applications are considered to be high-tech applications (Acar & Diken, 2012; Gardner & Wolfe, 2013). Studies conducted over children with ASD using robotics were also excluded as these are to be assessed in a separate study.

Sixty-five international and two domestic studies were found that met the above criteria. A total of 67 studies were scrutinized in two different categories (studies conducted with portable smart devices and those with computers); the studies in both categories were further assessed based on the skills the studies focused on, the software programs utilized in these studies' evaluations are presented in a separate table.

Parallel with this study's objectives, studies available in the literature were searched in electronic databases (EBSCO-Host, Google, National Thesis Center) using specific keywords, which yielded the 67 studies above. Keywords (*autism and technology*, *autism and computer*, *autism and tablet*, *autism and iPad*, and *autism and portable devices*) were used during the article search.

Data Analysis

The collected articles have been divided into two categories in this study: (a) studies conducted over individuals with ASD using computers and (b) studies conducted over individuals with ASD using smart devices. After being divided into two categories, the articles in each category were assessed based on the targeted areas of skills. Studies conducted using computers were evaluated after being sub-divided into academic skills, communication skills, social-affective skills, and other skills, while the studies conducted using smart devices were assessed under the sub-divisions of academic skills, communication skills, social skills, other skills, and comparative studies. A detailed analysis was conducted to comparatively evaluate the subjects and their characteristics, the targeted skill, research design utilized in each study, high-tech applications implemented in each study, and each study's research findings.

Findings

The findings of this study were analyzed based on two categories: individuals with ASD using computers and individuals with ASD using portable smart devices.

Studies Conducted over Individuals with ASD Using Computers

In this category, studies conducted over individuals with ASD are analyzed based on the sub-divisions of academic skills, communication skills, social-affective skills, and other skills. Only one study among the scrutinized articles was considered directly appropriate for the sub-divisions of both communication and social-affective skills and, as such, was assessed under both (Simpson, Langone, & Ayres, 2004).

Computer use in teaching academic skills. Analyzing studies conducted over individuals with ASD using computers showed that 16 subjects participated in these studies. The subjects were between the ages of 5 and 12 (M = 8.5). Fourteen were male (88%) and two (12%) were female. Brief analysis of the studies conducted on the instruction of academic skills using computers is presented in Table 1.

Assessing the preferred target skills for teaching academic skills demonstrated that one study favored skill instruction for writing stories (Pennington, Ault, Schuster, & Sanders, 2010). Three studies among the scanned articles presented reading skills using computer-based methods (McKissick, Spooner, Wood, & Diegelmann, 2013;

Whitcomb, Bass, & Lusielli, 2011; Yaw et al., 2011). Pairing skills (Kelly, Green, & Sidman, 1998), associative response skills (Kilroe, Murphy, Barnes-Holmes, & Barnes-Holmes, 2014), and skills for forming sentence structure (Yamamoto & Miya, 1999) were observed being taught in other studies.

Analyzing studies that utilized computer-aided application for teaching academic skills in terms of research design demonstrated that six studies used the single-subject research model. Three of these studies were designed based on the between-subjects multiple-survey model (Kilroe et al., 2014; McKissick et al., 2013; Pennington et al., 2010), and two were designed based on the inter-behavioral multiple-survey model (Whitcomb et al., 2011; Yaw et al., 2011). Only one study was conducted as a case study (Kelly et al., 1998), and only one utilized the pretest-posttest model (Yamamoto & Miya, 1999).

Examining studies that utilized computer applications showed that two of the studies taught using PowerPoint (McKissick et al., 2013; Yaw et al., 2011). Different software programs were used in the remaining studies: Visual Basic (Kilroeet al., 2014), Clicker 5 (Pennington et al., 2010), Headsprout (Whitcomb et al., 2011), and Desktop Bus Mouse (Yamamoto & Miya, 1999). In only one study was the software designed specifically for the research (Kelly et al., 1998).

Analyzing studies in terms of their findings demonstrated that using computers was effective at developing children with ASD's academic skills. All participating subjects achieved the required skills by the end of the application. A comparative study was conducted in one particular study (Kelly et al., 1998), where the subject's aural/visual perception skills were compared using a computer. Study findings demonstrated that the subject was more successful in pairing skills using auditory perception.

Computer use in teaching communication skills. Ninety-three subjects participated in studies that scrutinized computer-aided instruction of communication skills for individuals with ASD. The subjects were between the ages of 3 and 17 (M = 10). Seventy-three subjects (78%) were male and 20 (22%) were female. Analyzing participants' characteristics showed that most subjects had mild or medium levels of autism. Subjects with severe autism participated in only three studies (Bernard-Optiz, Sriram, & Sapuan, 1999; Bosseler & Massaro, 2003; Moore & Calvart, 2000). A brief analysis of studies that used computer-aided instruction for communication skills is displayed in Table 2.

As a result of analyzing target skills preferred for teaching communication skills, five studies were determined to aim at teaching words within the context of receptive language skills (Bosseler & Massaro, 2003; Coleman-Martin et al., 2005; Hetzroni &

Sahlem, 2005; Massaro & Bosseler, 2006; Moore & Calvart, 2000). Only two studies aimed to develop the subjects' oral narrative skills (Bernard-Optiz et al., 1999; Shih, Chiang, Wang, & Chen, 2014). Just two studies included conversation skills (Hetzroni & Tannous, 2004; Simpson et al., 2004). Detailed analysis of the studies showed only two studies that aimed for subjects to achieve phonetic awareness (Heimann, Nelson, Tjus, & Gillberg, 1995; McGonigle-Calmers, Anderson-Day, Fleming, & Monsen, 2013). Just one study performed satire instruction (Glenwright & Agbayewa, 2012).

Evaluating the research designs utilized in the studies demonstrated that seven studies used the single-subject research model (Bosseler & Massaro, 2003; Coleman-Martin et al., 2005; Hetzroni & Sahlem, 2005; Hetzroni & Tannous, 2004; Massaro & Bosseler, 2006; Shih et al., 2014; Simpson et al., 2004). Two quantitative studies analyzed the findings statistically (Heimann et al., 1995; McGonigle-Calmers et al., 2013). Additionally, one study used the pretest-posttest model (Moore & Calvart, 2000), one used the simultaneous application model (Bernard-Optiz et al., 1999), and one used a mixed model (Glenwright & Agbayewa, 2012).

Analyzing computer technologies utilized in the studies demonstrated that researchers developed special software for five studies (Hetzroni & Sahlem, 2005; Hetzroni & Tannous, 2004; Moore & Calvart, 2000; Shih et al., 2014; Simpson et al., 2004). Otherwise, researchers developed application materials using multimedia presentation tools (i.e., PowerPoint, HyperStudio). These applications contain instructional materials that enabled them to prepare themselves before studying with the subjects (Coleman-Martin et al., 2005; Simpson et al., 2004). Among the studies, two utilized the animated speech software, Baldi/Timo (Bosseler & Massaro, 2003; Massaro & Bosseler, 2006). Furthermore, researchers were observed in their studies to utilize software such as IBM Speech Viewer System (Bernard-Optiz et al., 1999), The Bubble Dialogue (Glenwright & Agbayewa, 2012), The Alpha Program (Heimann et al., 1995), and Macromedia Flash 5 (McGonigle-Calmers et al., 2013). Analyzing the hardware used in studies demonstrated that only one had used a laptop computer (Massaro & Bosseler, 2006), while desktop computers were used in others.

Examining the studies' findings demonstrated that computer use was effective at developing the subjects' communication skills. Only one study's findings showed that 3 out of 13 subjects had been unsuccessful at achieving syntactic awareness compared to the other subjects (McGonigle-Calmerset et al., 2013).

Computer use for teaching social-affective skills. Analyzing studies that scrutinized computer use for teaching social-affective skills to individuals with ASD reflected that a total of 398 subjects had participated in these studies. The subjects were between the ages of 5 and 52 (M = 28.5). Two hundred and ninety-one (73%) subjects were male and 58 (15%) were female; the gender of 49 (12%) subjects had

not been not determined. A brief analysis of the studies that utilized computers for teaching social-affective skills is presented in Table 3.

Analyzing the studies' preferred target skills in teaching social-affective skills showed that eight studies were conducted on face-recognition and emotional-comprehension skills (Bekele et al., 2014; Faja, Aylward, Bernier, & Dawson, 2008; Golan & Baron-Cohen, 2006; Lacava, Rankin, Mahlios, Cook, & Simpson, 2010; Matsuda & Yamamoto, 2014; Rice, Wall, Fogel, & Shic, 2015; Silver & Oakes, 2001; Tanaka et al., 2010). Among the skills studied were problem solving (Bernard-Optiz et al., 2001), telling creative stories (Dillon & Underwood, 2012), achieving social skills (Hopkins et al., 2011), showing facial expressions (Gordon, Pierce, Barlett, & Tanaka, 2014), vocally greeting peers (Simpson et al., 2004).

Evaluating studies that used computers for teaching social-affective skills in terms of research design utilized demonstrated that six studies were conducted using the experimental design with control group (Bekele et al., 2014; Bernard-Optiz et al., 2001; Dillon & Underwood, 2012; Faja et al., 2008; Golan & Baron-Cohen, 2006; Tanaka et al., 2012). Among the studies assessed under this category were two that utilized the pretest-posttest model (Gordon et al., 2014; Silver & Oakes, 2001). Three studies were designed with single-subject research models. Two of these studies were conducted using the between-subjects multiple-survey model (Lacava et al., 2010; Matsuda & Yamamoto, 2014), and one was designed using the inter-behavior multiple-survey model (Simpson et al., 2004). Three studies were conducted using the mixed-model (Hopkins et al., 2011; Rice et al., 2015; Tanaka et al., 2010).

Examining the computer technologies utilized in studies indicated that one was conducted using multimedia tools (PowerPoint; Faja et al., 2008). In one study, researchers also developed a special software program (Matsuda & Yamamoto, 2014). Furthermore, two studies utilized the same program (MindReading; Golan & Baron-Cohen, 2006; Lacava et al., 2010). The following software programs were also used in the studies scrutinized under this category: Unity (a game; Bekele et al., 2014), I Can Problem Solve (Bernard-Optiz et al., 2001), Bubble Dialogue (Dillon & Underwood, 2012), FaceMaze (Gordon et al., 2014), FaceSay (Hopkins et al., 2011; Rice et al., 2015), Emotion Trainer (Silver & Oakes, 2001), HyperStudio 3.2 (Simpson et al., 2004), and Let's Face It! (Tanaka et al., 2012).

Analyzing the studies' findings demonstrated that computer use was effective at developing subjects' social-affective skills. Groups that were applied the independent variable achieved the targeted skills in studies that compared individuals with ASD (Fajaet et al., 2008; Hopkinks et al., 2011; Riceet et al., 2015; Silver & Oakes, 2001). In other studies, individuals with ASD were compared to their normally developed peers. Although individuals with ASD demonstrated lower developmental

performance compared to their peers, increases were observed in their rates of proper behavior (Bekele et al., 2014; Bernard-Optiz et al., 2001; Dillon & Underwood, 2012; Funahashi, Gruebler, Aoki, Kadore, & Suzuki, 2014; Golan & Baron-Cohen, 2006; Gordon et al., 2014; Tanaka et al., 2012).

Computer use for teaching other skills. In this category, seven studies were reviewed that taught various skills to individuals with ASD. A total of 94 subjects were observed to have participated in these studies. Fifty-three (56%) of these participants were male, and seven (8%) were female; thirty-four (36%) participants' genders had not been identified. The following skills were determined as the target skills in the scrutinized studies: (a) interview for counseling (Barrow & Hannah, 2012), (b) visual-spatial skills (Chabani & Hommel, 2014), (c) cooperation with peers (Shih, Chiang, & Shih, 2015), (d) recognizing others (Holt & Yuill, 2014), (e) job interviews in a virtual environment (Smith et al., 2014), and (f) use of computer-aided activity schedules (Ülke-Kürkçuoğlu, Bozkurt, & Çuhadar, 2015). A brief analysis of computer-aided instruction of other skills is displayed in Table 4.

Evaluating studies in this category in terms of implemented research design indicated that two studies had utilized the experimental design with control groups (Chabani & Hommel, 2014; Smith et al., 2014). Among the scrutinized studies, only one had implemented activity research (Barrow & Hannah, 2012). In the study conducted by Holt and Yuill (2014), the between-subjects repeated-measures design (within-subjects design) was used. Two studies implemented single-subject research models. In one of these, the ABAB model was used (Shih et al., 2015), while the other implemented the between-subjects multiple-survey model (Ülke-Kürkçüoğlu et al., 2015).

Analyzing computer technologies used in these studies indicated that only one study used the multimedia tool, PowerPoint (Ülke-Kürkçüoğlu et al., 2015); all other studies utilized programs that required educational software (Barrow & Hannah, 2012; Chabani & Hommel, 2014; Shih et al., 2015; Dickinson & Place, 2014; Holt & Yuill, 2014; Smith et al., 2014). As a result of these studies' findings, computer use can be argued as effective at acquiring targeted skills. In Chabani and Hommel's (2014) study, children with ASD were compared to 40 male and 56 female students (M = 9) who demonstrated normal development. Although the children with ASD demonstrated lower attainment levels in the targeted skills, an increase in their proper behavior percentages was observed.

Studies Conducted over Individuals with ASD Using Portable Smart Devices

In this section, studies conducted using portable smart devices over individuals with ASD are scrutinized within the sub-categories of academic skills, communication skills, social skills, other skills, and comparative studies. Only one study was assessed

under both the communication skills and comparative studies sub-divisions due to its direct relevance to both subjects (Flores et al., 2012).

Use of portable smart devices in the instruction of academic skills. Six studies were reviewed in which portable smart devices were utilized for teaching academic skills to individuals with ASD. A total 26 subjects were included in these studies. The subjects were between five and 13 years old. Twenty-three (86%) subjects were male, while three (14%) were female. A brief analysis of the studies conducted on the use of portable devices for teaching academic skills is presented in Table 5.

Detailed analysis of the studies based on the targeted skills indicated that four studies were conducted on reading, functional reading, writing, and listening skills (Carnahan, Basham, & Musti-Rao, 2009; Eliçin, 2015; Pennington, Belva, Donald, Kennedy, & Karen, 2013; Spooner, Ahlgrim-Delzell, Kemp-Inman, & Wood, 2014). In the other studies, the aim was to teach scientific and mathematical terms using portable smart-technology applications (O'Malley, Lewis, Donehower, & Stone, 2014; Smith, Spooner, & Wood, 2013). All studies conducted with portable smart devices were observed to utilize single-subject research models.

In three studies conducted with portable devices for teaching academic skills, researchers were determined to have developed study-specific software (Carnahan et al., 2009; Eliçin, 2015; O'Malley et al., 2014). The following software were also observed to be used in the scrutinized studies: Keynote (Smith et al., 2013), Go Talk Now (Spooner et al., 2014), and Pixwriter (Pennington et al., 2013).

Analyzing the studies' findings demonstrated that using portable devices can be effective for individuals with ASD to achieve academic skills (Carnahan et al., 2009; Eliçin, 2015; O'Malley et al., 2014; Spooner et al., 2014).

Use of portable smart devices for teaching communication skills. Twelve studies were observed to utilize portable smart devices for instructing individuals with ASD in communication skills. In these studies, 37 subjects were identified to have participated. They were between three and 17 years old ($M = 10$). Twenty-five (67%) subjects were male and 12 (33%) were female. Reviewing the participating subjects' special-needs levels showed that most subjects suffered from mild or medium ASD. A brief analysis of the studies conducted on the use of portable devices for teaching communication skills is presented in Table 6.

Analyzing the studies based on targeted skills indicated that seven studies targeted the skill of initiating communications (Ganz, Hong, Goodwyn, Kite, & Gilliland, 2015; Gevarter et al., 2014; Kagohara et al., 2012; Leo, Gonzales, Battagiri, & Leroy, 2011; Sigafoos et al., 2013; Waddington et al., 2014; Xin & Leonard, 2014). In three other studies, achieving functional communication skills was identified as

the aim (Desai, Chow, Mumford, Hotze, & Chau, 2014; M. L. King et al., 2014; Ward, McLaughlin, Neyman, & Clark, 2013). Only one study preferred to research imitating sounds (Flores et al., 2012), and another one to research receptive language skills (Still, May, Rehfeldt, Whelan, & Dymonda, 2015).

Evaluating studies in this category in terms of research design used indicated 10 studies had implemented single-subject research design (Flores et al., 2012; Ganz, Hong, Goodwyn, Kite, & Gilliland, 2015; Gevarter et al., 2014; Kagohara et al., 2012; M. L. King et al., 2014; Sigafoos et al., 2013; Still et al., 2015; Waddington et al., 2014; Ward et al., 2013; Xin & Leonard, 2014). Only two studies were conducted as case studies (Desai et al., 2014; Leo et al., 2011).

Reviewing the applications used in this section's studies reveal that Proloquo2Go software was used in three studies (Kagohara et al., 2012; M. L. King et al., 2014; Waddington et al., 2014). The program Go Talk Now, which was developed for communication skills and can transfer symbols into sounds, was used in three studies (Desai et al., 2014; Gevarter et al., 2014; Ward et al., 2013). One study indicated integrating the PECS method in portable smart devices using the PECS Phase III App (Ganz et al., 2015). Pick a Word (Flores et al., 2012), PixTalk Smart-Phone (Leo et al., 2011), Toy Play Symbol (Sigafoos et al., 2013), and SonoFlex (Xin & Leonard, 2014) were used in other studies.

Analyzing the studies' findings resulting from portable smart devices for teaching communication skills demonstrated that these studies were effective at developing individuals with ASD's communication skills (Desai et al., 2014; Gevarter et al., 2014; Ward et al., 2013; Xin & Leonard, 2014).

Using portable smart devices to teach social skills. Two studies were scrutinized that had been conducted over instructing social skills to individuals with ASD. Twenty-nine subjects were identified to have been included in these studies. The subjects were between the ages of 4 and 14 ($M = 9$). Seventeen (52%) were male and 12 (48%) were female. A brief analysis of the studies conducted on using portable devices to teach social skills is displayed in Table 7.

Analyzing the studies evaluated in this category in terms of targeted skills demonstrated that studying skills (Hourcade, Bullock-Rest, & Hansen, 2012) and teaching social stories were targeted (Vandermeer, Beamish, Milford, & Lang, 2015). While Hourcade et al. (2012) conducted their study as a case study, Vandermeer et al. (2015) utilized the multiple baseline model, one of the single-subject models. Reviewing the applications used in these studies indicated that Hourcade et al. (2012) utilized the Python-Based application in their study, while Stories2Learn application was used in Vandermeer et al.'s (2015) study. Analyzing the studies' findings

demonstrates that using portable smart devices can be effective at teaching social skills to individuals with ASD.

Portable smart device usage for teaching other skills. Nine subjects were identified to have participated in studies conducted on instructing other skills to individuals with ASD. They were between the ages of 3 and 7 (M = 5). Seven (78%) subjects were male and two (22%) were female. A brief analysis of the studies conducted on portable devices used to instruct other skills is presented in Table 8.

Reviewing the studies evaluated in this category in terms of the targeted skills demonstrates that skills such as associative response (King, Thonrieczek, Voreis, & Scott, 2014), imitation games (Murdock, Ganz, & Crittendon, 2013), and problem-behavior treatment (Neely, Rispoli, Camargo, Davisve, & Boles, 2013) were targeted in the studies. Assessing the research models that the studies used reveals that all studies were designed with single-subject research models. The preferred designs among these models were the between-subjects multiple survey method by A. M. King et al. (2014), the between-subjects multiple baseline model by Murdock et al. (2013), and the ABAB model by Neely et al. (2013).

The use of Proloquo2Go (A. M. King et al., 2014), Keynote (Murdock et al., 2013), and Little Matchups (Neely et al., 2013) applications were identified in these studies. Analyzing the studies' findings demonstrated that portable smart device usage can be effective at achieving the targeted skills for individuals with ASD.

Studies comparing portable smart device implementations. Six studies were found to compare portable smart devices. Forty-three subjects were included in these studies. The subjects were between the ages of 3 and 16 (M = 9.5). Thirty-four (79%) subjects were male and nine (21%) were female. Most studies compared non-technological applications to smart applications. A brief analysis of the studies comparing portable smart-device applications is presented in Table 9.

Among the studies evaluated in this category, four studies were identified that had compared the Picture Exchange Communication System (PECS) application to portable smart applications (Allen, Hartleyand, & Cain 2015; Chien et al., 2015; Hill & Flores 2014; Lorah et al., 2013). In addition, an iPad application was compared to one conducted with picture cards (Flores et al., 2012). Two portable smart-device applications were compared in only one study (Dundon, McLaughlin, Neyman, & Clark, 2013).

Evaluating the studies in this category in terms of research models used reveals one qualitative study (Chien et al., 2015), and one study that used an empirical design model (Allen et al., 2015). The remaining four studies were conducted using single subject research models (Dundon et al., 2013; Flores et al., 2012; Hill & Flores, 2014; Lorah et al., 2013).

In two of the related studies, Proloquo2Go (a smart application) was compared to the conventional PECS method (Hill & Flores, 2014; Lorah et al., 2013). While PECS was compared to an application that the researchers had designed in their study (Allen et al., 2015), Chien et al. (2015) compared PECS to the iCAN application. In addition, one study compared iPad applications to those utilizing picture cards (Flores et al., 2012).

The findings of the studies scrutinized in this category demonstrate that the compared applications were effective, however iPad had the advantage of ease of use as a technological device (Lorah et al., 2013); it would be efficient to begin teaching with PECS when working on children with ADS's communication skills, and continue with iPad applications later (Hill & Flores, 2014); applications are effective for learning motivation and the sustainability of learning (Chien et al., 2015); iPads do not provide significant differences in learning output but do motivate special needs individuals (Allen et al., 2015). In addition, the My Choice Board application was found to be more quickly effective when compared to the Go Talk Now Free application (Dundon et al., 2013).

Discussion

In this study, 67 different studies conducted using high-tech devices over individuals with ASD were analyzed based on certain criteria under different categories. The findings were scrutinized comparatively by dividing the studies into the categories of studies that utilized computers and those that used smart devices. Thirty-nine studies (58%) conducted using computers and 28 studies (42%) conducted using portable smart devices were assessed.

Based on the years that these studies were conducted, four studies were identified to have been conducted between 1995 and 1999; seven were conducted between 2000 and 2004; six were conducted between 2005 and 2009; and lastly, 49 were conducted between 2010 and 2015. The number of studies conducted over individuals with ASD using high-technologies was observed to have increased significantly since 2010. Reviewing the number of studies in both categories published since 2010 showed that 23 studies were conducted with computers and 26 with portable devices. This increase was considered to be due to the ease of accessing not only technology but also the findings of other studies conducted over individuals with ASD using high-tech devices. Furthermore, studies were observed that had been conducted using computers before 2005, while no study had been conducted with portable smart devices before then. This finding shows that portable smart devices were not prevalent before 2005 compared to computers.

Analyzing the participants' age range in these studies showed 19 studies were conducted with 2-7 year-old subjects, 28 studies were conducted with 8-12 year olds,

and 18 studies were conducted with 12-18 year olds. Two studies did not provide information on the subjects' ages. Thus one can argue that mostly subjects between 8-12 years old were included in studies conducted over children with ASD using high-tech devices. In the category of studies conducted with computers, eight studies were determined to have been conducted with 2-7 year-old subjects, 18 studies were conducted with 8-12 year olds, and 13 studies were conducted with 12-18 year olds. In the category of studies conducted with portable smart devices, 11 studies were identified to have been conducted with 2-7 year-old subjects, 10 studies were conducted with 8-12 year olds, and five studies were conducted with 12-18 year olds. Based on these results, one can argue that 8-12 year olds were preferred more in both groups of studies. Furthermore, while portable smart devices were observed to be preferred more with the 2-7 year-old subjects, computers were preferred more with the 12-18 year olds. This result could be interpreted as using portable smart-device is easier than computers for younger individuals.

The skill areas planned for individuals with ASD in studies conducted using high-tech devices were assessed in detail. The results of this analysis indicated that 24 of these studies were on communication skills, 15 were on social-affective skills, 13 were on academic skills, nine were on other skills, and six were comparative studies. Thus, these results demonstrate that studies conducted over children with ASD using high-tech devices aimed mostly at developing communication skills. Following communication skills, the majority of studies were conducted on the areas of social-affective skills and academic skills. Based on the study categories, studies conducted using computers were concentrated on social-affective skills while studies conducted using portable smart devices were mostly focused on communication skills. Studies conducted using computers were concentrated less on academic and other skills, while only a few studies were conducted on social skills using portable smart devices.

Evaluating the research models utilized in the scrutinized studies showed that 39 studies out of 67 were designed using single-subject research models. The least used research model was determined to be the pretest-posttest model. Among the studies conducted using high-tech devices, the studies conducted with computers were predominantly identified to utilize single-subject designs and experimental designs with control group. On the other hand, studies conducted with portable smart devices preferred mostly single-subject research models. It is an expected fact that these studies would utilize single-subject research models. One can argued that this is due to the difficulties in finding similar subjects with the prerequisite characteristics.

Detailed analysis of software and computer programs used in these studies indicate that researchers developed more software for studies conducted using computers than those conducted using portable smart devices. This could be due to computer

technology being older than portable smart-device technology, as well as more tools being available for developing software on computers. Furthermore, one can argue that the ease of downloading software to portable smart devices compared to computers could have resulted in researchers preferring existing programs in their studies.

There are certain limitations to this study. The studies were obtained through electronic databases that contained articles published between 1995 and 2015 in peer-reviewed journals. Studies that did not meet these criteria were excluded. Furthermore, this study is limited to studies utilizing high-tech devices conducted over children diagnosed with ASD. The studies obtained within this context were not evaluated for inter-rater reliability, application reliability, or social validity. However, certain recommendations could be given for further studies. Primarily, the number of studies on individuals with ASD using high-tech devices is very low and should be greater. More individuals diagnosed with ASD can be included in studies conducted using high-tech devices, and the efficiency of the utilized technology could be analyzed. The number of studies on developing individuals with ASD's social-affective skills using portable smart devices could be increased. In addition, the number of studies using high-tech devices for teaching academic skills could be increased. The number of studies that utilize portable smart devices for teaching 12-year-old or older children with ASD could be increased.

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