A Spectrum of Tech:

An Integrated Literature Review of Technologies to Target Social Skills in Students with Autism Spectrum Disorders

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Abstract

Students with autism spectrum disorders (ASD) often have limited social or communication skills and, thus, need extra assistance in learning when and how to engage in appropriate interactions with those around them. However, because there are several different individual skills (e.g., joint attention, emotional expression, etc.) that fall under the categories of social and communication skills, and there are even more options of devices and programs to choose from within assistive technology (AT) and instructional technology (IT), it may seem daunting to find the right technology to meet a specific child's needs and to determine whether that technology procedures lasting results. The purpose of this integrated literature review was to investigate whether devices used for social skills intervention in PreK-12 students with ASD function as either AT or IT, with the secondary goal of determining which technologies promote better maintenance and generalization than others in social skills interventions in PreK-12 students with ASD. Analysis of published research studies on Virtual Reality, Augmented Reality, Games, Video Modeling, Social Robots, and Wearable Assistive Technologies demonstrate that many of these technologies function as either AT or IT, depending on the context of the situation. Furthermore, it was found that certain devices, specifically Video Modeling and Social Robots, promote better maintenance and generalization.

Keywords: assistive technology, instructional technology, autism spectrum disorder, social skills, generalization, maintenance

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In the 21st-century, technology has opened and continues to open a realm of opportunities and possibilities for people of all ages and backgrounds. Technology has helped to send people to the moon, perform complicated surgeries, break codes, and now to help all autistic students engage with others to the fullest extent possible. Both assistive technology (AT) and instructional technology (IT) have their place in the field of social skills education and have brought to attention the potential they have to engage PreK-12 students with ASD and help them build their social abilities so that they gain practical and lasting skills to use for the rest of their lives. The purpose of this integrated literature review is to examine the technologies that best serve students with ASD as they learn, maintain, and generalize social skills.

The Role of Technology in Education

In order to discuss the relationship between technology and the social skills of students with ASD, it is imperative to first define technology as it applies to and is used in the field of education. One definition of technology coins it as “any electromechanical tool which can help an individual accomplish work, enjoy leisure pursuits, and get assistance” (Ennis-Cole, 2015, p. 13). In this review, however, when I refer to technology I am referring to the implied employment of devices, tools, and programs that are used to accomplish a goal. Within the educational sphere, there are basically two categories of technology: assistive and instructional.

Assistive Technology

Defining assistive technology (AT) can be a difficult task because of the many applications of the various devices that fall under the umbrella of AT. *Assistive* is defined as something or someone that provides “aid or assistance” (Merriman-Webster, n.d.). While simple, this definition accurately describes the role of AT in the education of students with disabilities. According to the Assistive Technology Act (2004), a more precise definition of AT is “any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities” (Sec. 3, para. 7). In keeping with this definition, there are numerous examples of devices that could be categorized as AT and, subsequently, there may be different uses for students with various disabilities.

One of the main goals of AT is to provide added support for students beyond what they typically receive within the general curriculum (Shepley et al., 2017). When students require such supports, they are evaluated for assistive technology services through special education so that they receive the appropriate device for their specific needs. Under the Individuals with Disabilities Education Improvement Act (IDEA), the governing law of special education, assistive technology service is “any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device” (Sec. 3, para. 5). More specifically, these services may come in the form of evaluations, purchasing of AT, customizing the device, working with and training other professionals and services, training parents, or working with the student.

AT services are often provided to a student for use in education-related settings since that is the environment in which the student's needs are typically identified. Most often, once the needs of the student are evaluated and the appropriate technology is selected, the teacher and all other involved professionals are trained on the use and implementation of the device. This is one of the first steps taken to ensure fidelity of implementation with regard to the AT; fidelity of implementation ensures that a treatment or tool such as a device is used as it was designed (Stains & Vickrey, 2017). Teachers whose goal is to follow fidelity of implementation ensure that they understand the device, utilize available resources, and always adhere to the instructions that accompany the piece of technology. Because AT is typically part of a student's Individualized Education Plan (IEP), it is especially important that the device is used as designed in order for the student's goals to be met and to ensure safety and educational progress.

Instructional Technology

The other categorization for technology in education is instructional technology (IT). This category is not officially defined by the Assistive Technology Act of 2004 and is sometimes open to interpretation depending on the context and use (Shepley et al., 2017). The Association for Education Communications and Technology (AECT), however, does provide some guidance with its definition of educational technology, which is "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (AECT, 2008, p. 1).

While some believe that educational and instructional technology are synonymous, others believe that the two terms have distinct meanings. AECT (2008) points out that “one of the critical elements of instructional design is to identify the learning tasks to be pursued and to choose assessment methods to measure their attainment” (pp. 4-5). This is different from the definition of educational technology mentioned earlier which suggests a broader approach through generalized wordings such as “facilitating learning and improving performance” and “technological processes and resources” (p. 1). This view is strengthened by the Commission on Instructional Technology’s definition of IT which includes the phrase “teaching in terms of specific objectives” (p. 19). Furthermore, in 1977, AECT distinguished between the two terms by saying that educational technology was used in “all aspects of human learning” (p. 1) while IT was seen where “learning is purposive and controlled” (p. 3). The usage of the term “educational technology” in lieu of “instructional technology” in the 2008 definition by AECT shows the dynamic relationship between the two as they are both still in use (Ibrahim, 2015). For the purposes of this study, since technology will be viewed in light of instruction, generalization, and maintenance, the term “instructional technology” will be used.

Because IT is used to teach a variety of new skills to meet specific objectives, it is often used in many different settings both in and out of the educational sphere (Shepley et al., 2017). For example, a teacher may have students practice math facts using a mobile application at school and then ask them to complete the activity at home on their family’s computer. Because the goal of the technology (the application) is to teach a skill (math facts) that will eventually be performed without the technology, it is clear that the piece of technology is instructional. It may also be seen from this example that educators and students with special needs are the only individuals who use instructional technology.

Because the majority of students will need to spend time practicing math facts, however, it is clear that general education students and their teachers benefit from instructional technology as much as special education students and their teachers.

Generalization and Maintenance

Generalization occurs when a student is able to use what is learned in one environment and apply it to new places and with new people (Smith et al., 2016). For example, if a student is taught to make eye contact when greeting the teacher at the beginning of the school day, the student should also be able to make eye contact with a doctor at a yearly visit. If students only learn skills as applying only to the situation in which they are taught, they will likely fail when the skill is needed in another environment (Mastropieri & Scruggs, 2018). This, however, does not prepare students for life experiences where one skill set is often used in a variety of contexts.

Maintenance works in check with generalization as it means that a student is able to sustain the skill over time (The IRIS Center, 2014a). For example, the student who learns to make eye contact with the teacher at the beginning of the school day in September should not lose this skill by December. The time period can be either short-term, as in a few months, or long-term, as in several years or more. These two concepts illustrate the necessity for technology being used both in and out of school.

The Intersection of AT and IT

While AT and IT clearly have their differences, there are many situations in which it may be difficult to determine into which category the technology falls (Shepley et al., 2017). For example, a teacher may use beanbags as part of a learning activity with kindergarten students. In this activity, the students must toss the bean bags into the basket of the same color and say the color as they do so. This activity simply allows students to practice their knowledge of colors and the students will not need to use bean bags every time they want to identify an object's color. Because of the beanbag's purpose in this example, it is considered IT as it teaches a skill as opposed to providing long-term support. Conversely, should an English teacher use those same bean bags as wrist supports for students with orthopedic impairments while they are typing their essays on the computer, the bean bags would be AT because they are providing an additional functional support needed by the students to complete a task (Assistive Technology Act, 2004). In these two examples, it is clear to see the intersection of AT and IT: one device can suit the purposes of both categories of technology.

Thus, the question can now be asked: is it important to hold firmly to the definitions of AT and IT if the technology meets students' needs? The answer to that question is both yes and no. In accordance with the concept of social validity, it is important for an intervention (or, in this case, technology) to teach and improve behavior so that the new behavior is socially acceptable (Shepley et al., 2017). Thus, if it is more socially acceptable for a certain behavior to be performed in the absence of technology than with it and the IEP team believes the student is able to reach this standard, then the device should function as IT, if possible. On the contrary, if the student is incapable of reaching this social standard or there is no standard, then the device could function as AT. With regard to social validity, therefore, the differences between AT and IT matter. There are, however, times when the intention to use a device as AT may be short-lived when the device ultimately functions as IT or vice-versa. When this occurs, the team must assess the effect the device has on the student and whether or not the best possible outcome was achieved. It is in these cases that team will most clearly see the blurred line between AT and IT and may desert the original plan in favor of the new direction that the technology has naturally taken.

Social Skills in Children with ASD

Researchers note that one of the two major characteristics of ASD is a difference in social communication and interaction (Parritz & Troy, 2018). Oftentimes, educators simply refer to this area as “social skills” since both communication and interaction are skills required to function successfully in social environments. While the families of typically-developing students may take their child’s level of social functioning for granted, families of students with ASD know that even the smallest gains toward positive social interaction should be celebrated.

Characteristics

For students with ASD, interacting with others of all ages does not often come easily. In fact, according to Volkmar and van der Wyk (2017), Leo Kanner first used the term *autism* to describe the group of individuals because the term means a “lack of interest in others” (p. 11). Kanner believed that the two cardinal features of the diagnosis were the aforementioned and a strong aversion to change. Within the name of the disorder itself, then, lies this prominent struggle. Some have even proposed that autism should be considered a social learning disorder. The learning process is often a very social experience for students, and so it is incredibly important to find the most effective ways to provide social skills intervention so that this group of children will be able to access the education they deserve.

It may be asked whether or not all students with ASD exhibit the same difficulties in social functioning and whether or not they experience them to the same degree. There have been numerous studies conducted that have attempted to answer this question, however, because each considered different variables and methods for research, the results are inconclusive (Syriopoulou-Delli, 2018). Because of this, a researcher in Greece chose to conduct a study that solely focused on the "relationship between the critical variables" (p. 37) and social functioning in children with ASD While it is known that there are differences in social behavior among students with ASD, the influence of individual variables was still unknown in the minds of the researchers. The study found that girls typically tend to interact positively more often than boys and, overall, age does not seem to play a major factor in socialization. The researcher also investigated whether or not the comorbidity, or coexistence, of an intellectual disability improved or inhibited positive social interaction. Syriopoulou-Delli found that when both disorders are present there tends to be an increased difficulty to function appropriately in social environments. Finally, students who were nonverbal tended to have more deficits in social functioning than those who were verbal, and children attending typical classes opposed to special schools or inclusion classes scored higher in social behavior assessments. Thus, while there are limitations to this study as with all studies, it begins to attack the inclusivity of the speculations of variations of social functioning in those with ASD.

Specific Social Skills

Just as there are many types of technology, there are also many types of social skills (Mastropieri & Scruggs, 2018). Students on the autism spectrum will have varying abilities in these specific skills and, as such, will not all need training in the same social skills. There are categories, however, that address many of the most common and prominent of struggles among individuals with ASD. These areas are not specific to any particular age group or grade-level but all play some role as prerequisites for skills needed to function successfully as an adult. In this review, no one skill takes precedence over another and all have been addressed using technology.

In this study, the following social skills were considered in relation to technology: joint attention, collaboration, emotion recognition, non-verbal communication, social initiation, and complimenting. Joint attention involves processing another person's face and then attending to whatever that person is attending (Mundy, 2016). When a student with ASD sees another person looking at a poster on the wall, for example, the student will also look at the same poster. Thus, both persons are visually and cognitively focusing their attention on the same object. Collaboration is similar in that it involves a shared focus and goal (Silva et al., 2016). In collaboration, however, students move one step further by working together to achieve their goal.

Students with ASD may also struggle with emotion recognition, which is simply "the processing of several types of stimuli, such as facial expression, vocal intonation, body language, [and] content of verbalization" (Golan et al., 2017, p. 844). These children may not recognize the difference between sadness and frustration, for example, when they look at another person. Similar to emotion recognition is non-verbal communication. In this domain, actions such as posture, facial expressions, and gestures serve as the means of communication (Hargie, 2018). When students with ASD do not understand how to interpret these means, they cannot identify the clues or messages that the other individual is relaying. Social initiations are also components of social skills.

Initiations occur when children take the first step in a social meeting to invite a peer to play, to greet the peer, or to engage in conversation (Kabashi & Epstein, 2017). Finally, compliments can include both verbal and nonverbal (for example, gestures) means for encouraging another person (Macpherson et al., 2015). These are the specific social skills that the included studies sought to address.

Method

One of several different types of literature reviews, the integrated literature review seeks to draw on either established and dynamic works or works that are new and emerging in order to develop a better and more holistic view of the topic at hand (Torraco, 2016). These types of reviews, according to Zorn and Campbell (2006), provide opportunities for the exploration of ideas and provide applications to the real-world. When ideas are explored and applied to the real-world, they help individuals make informed decisions by synthesizing credible information on a topic and providing it to the reader in a systematic and organized manner. Already-established topics with a wide body of existing research may be reviewed in order to revive interest in the field or to propose a new angle. New areas of study may benefit from an integrated literature review because of the awareness of the topic it will provide.

Goal and Purpose of this Integrated Literature Review

Identifying the goals and purposes of an integrated literature review is an essential component of the review itself (Torraco, 2016). The goal of this particular review was to synthesize existing literature on the effectiveness of particular devices used to teach or enhance the social skills of students with ASD to create a more complete picture of the effectiveness of these devices. Because the studies reviewed in the existing literature deal with unique individuals who all have distinct needs, it would be impossible to provide a definitive answer as to whether or not a piece of tech will always work for students in a given situation. It is possible, however, to consider the similarities and differences among studies and individuals to for a helpful picture of the devices that have proven most reliable and have achieved their desired results.

Because deficits in social skills are considered one of the major characteristics of individuals with ASD and these skills are vital components of an independent life, this study examined them specifically instead of the disability as a whole (Parritz & Troy, 2018). The specific social skills that are reviewed here were chosen based on their prevalence in the existing literature as some specific social skills have not yet been targeted for intervention with technology. Finally, while many different strategies can be used to train students in social skills, technology was chosen because of its growing inclusion in the classroom (Mastropieri & Scruggs, 2018).

A final goal of this study is to answer questions surrounding the intersection of technology, social skills, and students with ASD. It is possible that this review will spur future investigation into different questions; however, the questions that influenced this study are:

1. Could the devices used for social skills intervention in PreK-12 students with ASD function as either assistive or instructional technology?
2. Do certain pieces of technology promote better maintenance and generalization than others in social skills interventions in PreK-12 students with ASD?

Ethical Considerations and Reliability

During this integrated literature review, I desired to remain as unbiased as possible in order to provide a fair and reliable research product. Special care was taken to keep details organized in order to prevent a careless mishandling of information (Torraco, 2016). The literature and existing research examined in this integrated literature review are considered scholarly sources and have been through a peer-review process. The search for the literature included in this work were located by using search terms such as *technology and autism, assistive technology, instructional technology, social skills interventions.* These phrases were then entered into the EBSCO Quick Search, JSTOR, Academic Search Ultimate, and Education Research Complete and the resulting articles were examined for how well they addressed the research questions. From there, the references of the original articles were consulted for more specific search terms and the databases were searched again. A matrix was used to organize all of the sources, publication years ranging from 2015-2020, along with key words and topics.

Findings

The field of technology offers a wide and ever-expanding spectrum of devices from which to choose. Practitioners and parents have the job of evaluating the options and selecting the one that shows the most promise for their students. Because ASD is a spectrum of abilities, it is important to find interventions that can be customized to meet various needs. Technology provides this option and is, therefore, worthy of consideration for inclusion in educational plans for autistic students (Ennis-Cole, 2015). While some devices might fall into overlapping categories, there are six distinctive categories examined here in light of the research questions: augmented reality, games, mobile devices, robots, virtual reality, wearable assistive technologies.

Virtual Reality

When people think of virtual reality (VR), they may think of science fiction or a trip to an alternate universe. This, however, is not necessarily the case. VR is a current technology that can be used with students with ASD to improve social skills. Immersive Virtual Reality Systems (IVRS) are a form of VR that, as the name implies, immerses the user into a "three-dimensional representation of real environments that can be used repeatedly" (Lorenzo et al., 2016, p. 193). The IVRS uses a "semi cave" structure and camera facilitate the child and monitor his actions as he moves about (p. 195). In this particular study, researchers used the software Vizard to design the various environments and social situations used in the intervention.

Using 40 7-to-12-year-old students with ASD as participants, the researchers set up various social situations where the students had displayed difficulties (Lorenzo et al., 2016). These situations included gatherings such as birthday parties, school hallways, and field trips. The goal of the study was to train emotional responses that were appropriate to particular social situations. When the students entered the IVRS, they entered into the social situation and the evaluator proposed an appropriate behavior. The student either passed the situation or repeated the setting depending on whether or not the correct behavior was chosen. When compared with a group who only used VR, the IVRS group scored significantly higher on measures of behavior exhibited during the intervention.

Collaborative virtual environments (CVE) are virtual reality scenarios that allow multiple users in different locations to interact with one another in the virtual world

(Zhao et al., 2018). Zhao et al. sought to give students with ASD a safe and non-threatening environment in which to practice positive social interactions and to encourage engagement through gaming that requires collaboration and conversation. The devices used in this study were the created gaming program, a controller, headset and webcam, eye tracker, and other corresponding applications. Using Skype, the 12 students with ASD played eight games with a typically-developing partner (who was in another room), collaborating to perform various actions. The games became more difficult with time and students had to work as unified teams in order to succeed. After the intervention, the researchers determined that the technology functioned well for its purpose. Furthermore, the participants, through a questionnaire, reported that they enjoyed the game and valued the collaboration that occurred. The conversations that occurred during the intervention through Skype revealed that the students with ASD eagerly communicated with their partners during the game when they needed to share information, and many participants spontaneously spoke out with words of affirmation or pieces of information relating to their lives. This preliminary study on CVE shows promise that this technology could be a means to promoting spontaneous communication and interactions in social situations.

Both the IVRS and the CVE were used in an IT capacity because of the presence of specific objectives for learning and because the intervention provided a safe environment for the learning and practicing of skills. Notably, neither studies discussed here specifically tested for maintenance nor generalization. Lorenzo et al. (2016), however, did mention that when the tutoring teachers involved with the study commented on the students' progress, they reported that the skills learned in the IVRS were transferred to other areas of students' lives. Zhao et al. (2018) also noted that findings led them to believe that the CVE had the potential to spur spontaneous communication and interactions among students. Both studies, however, would need to conduct follow-up studies to test specifically for maintenance and generalization.

Augmented Reality

The second category of technology examined is augmented reality (AR). This technology is similar to virtual reality in that it immerses the user into a different environment, however whereas virtual reality thrusts the user into a new reality, AR adds new and virtual objects to the existing reality, thus augmenting it (Lorenzo et al., 2019). These objects are generated by a computer and laid over the view of the existing environment. Because of this feature, it is possible to take existing social situations and overlay them with instructional features, prompts, and directives for students with ASD.

The first study, conducted by Liu et al. (2017), viewed the feasibility of a Brain Power System (BPS), which is a "smartglasses-based augmented reality system for children and adults with ASD" (p. 2). The BPS was developed as a result of parents feeling disconnected from their children with autism, due to a lack of social functioning on the part of the child. The BPS supported different applications in the form of games with different modules addressing different issues. This study focused specifically on the social skills applications that address face and eye gaze as well as recognition of facial emotion. The application Face Game focuses on increasing the user's interest in attending to the faces of others, an action which is typically avoided by individuals with autism. Emotion Game*,* on the other hand, seeks to reinforce emotion recognition training that is typically provided by therapists. Both applications detect human faces and identify the feature in question (in this case, faces and emotions).

In Face Game, the user accumulates points by looking at certain parts of another's face while the device collects data on the patterns of behavior of the user. Emotion Game, on the other hand, provides different emotions for the user to choose from when viewing the face of another (Liu et al., 2017). The study was conducted with two male students, ages 8 and 9 years. Following intervention using both applications, the caregivers of the boys were interviewed to build a better understanding of the effects of the intervention. Both caregivers reported that the boys enjoyed and were engaged in the program. They also noticed improvements in non-verbal communication, eye contact, and social engagement. While verbal communication appeared to be unaffected, there was a reduction in all 5 subskills across the Aberrant behavior checklist (ABC) which includes behaviors such as stereotypic behavior and irritability/agitation.

The second study, conducted by Lorenzo et al. (2019), was similar to that conducted by Liu et al. (2017) in that it was a preliminary study and laid the groundwork for future research. In this study, the children with ASD used a program called Quiver Vision which was produced for use on Android devices. While one group of 6 children with ASD (the experimental group) used the program with a therapist to complete different social skills objectives, another group of 5 children with autism (the control group) had the same objectives but were trained without the use of Quiver Vision. In the intervention, Quiver Vision used AR to provide suggestions and rewards in a variety of different social situations. Upon analysis of both pre- and post- intervention test scores, neither the experimental nor the control group seemed to have an advantage over another as their scores were very similar. Upon reflection, however, it was observed that the experimental group who used AR were more engaged and motivated to complete the tasks presented to them by the therapist.

At this point, it is important to review the research questions to see what contributions these two studies provide to the existing body of knowledge. In both the study by Liu et al. (2017) and Lorenzo et al. (2019), the AR functioned as IT; this is evident through a few features. First, Liu et al. developed the BPS to include a variety of training modules that the student would progress through and master. Because the modules are able to be mastered and are not working in a functional capacity as they would should they be AT, it is clear that the BPS is IT in this situation (Assistive Technology Act, 2004). Furthermore, Lorenzo et al. did not test the children's improvement while using the technology; in fact, they examined how the children improved post-intervention, which implies that some sort of training occurs during the intervention which is then intended to inform the individual during realistic social situations. This is a function of IT, not AT.

Is AR capable of promoting generalization and maintenance? While neither of these two studies explicitly investigated this question, there are indicators within some studies that may provide additional information. In the case of Liu et al. (2017), even though they primarily sought to test the feasibility of the program, findings showed promising results in generalizability as the caregivers noticed changes in their children even after the device was removed and they interacted in different settings. While, Lorenzo et al. (2019) observed improved social skills with both the experimental group with technology and the control group without, they did not specify whether these skills were generalized to different settings or simply maintained in future therapy sessions.

Thus, because of the lack of information, it is not possible to conclusively determine whether AR promotes maintenance based on these two studies.

Games

It has been observed that children with ASD enjoy games and game-like elements embedded in technology (Liu et al., 2017). Different researchers have investigated the ability of games to foster social skills in students with ASD. Chung et al. (2016) specifically looked at social cognition which they define as “accurately integrating, interpreting, and responding to social cues” (p. 651). They compare online video games to virtual reality therapy as they provide “a safe environment, repeated practice and exposure, naturalistic environments, various social scenarios, and replicated social conditions” (p. 652).

For the study, researchers recruited 20 adolescents with autism between the ages of 13 and 18 years to compare the effects of an online game using Cognitive Behavior Therapy (CBT) versus those of offline-CBT (Chung et al., 2016). CBT is a therapeutic approach that systematically uses goals to address “dysfunctional emotions, cognitions, and behaviors” (Parritz & Troy, 2018, p. 276). The experimental group of students played the online game Poki-Poki while their therapist conducted CBT with them. Poki-Poki allows the user to engage with other users, give virtual gifts, and become friends with others (Chung et al., 2016). The control group did not play Poki-Poki during their CBT sessions. Therapists organized the sessions into different topics such as “body attitudes in conversation” and “understanding what other people are saying” (p. 653). Results indicated that both online and offline approaches were equally effective at improving the students’ social interactions. The online approach increased brain activity in ways that spurned better emotion recognition while the offline approach triggered better awareness of emotional words.

The next study, conducted by Mairena et al. (2019), also examined videogame technology but, instead of an online game, used a full-body interaction videogame. Researchers investigated whether or not students with ASD made social initiations more often when playing the game or when playing with other children. 15 Students with ASD ages 4-7 years old participated in an intervention using a Kinect sensor (a camera) that detects the child's movement; in front of the child is a screen depicting the gameplay environment in which the child is moving. The intervention consisted of four sessions, during which the student played in single-user mode (session 1), needed help from an adult (session 2), played with an adult (session 3), and played with another student with autism (session 4). As the student sought to complete the challenges in the game, researchers saw that the child did indeed initiate more social gestures when playing the game than when engaged in technology-free play.

The final study on game-based technology used a multitouch game to encourage social interaction among five students with ASD (Silva et al., 2014). Researchers developed strategies called Collaboration Patterns, which they define as "interaction strategies on elements in a multiuser interface that gradually encourage collaboration among people with ASD" (p. 151). To test their strategies, the researchers selected youth with autism between the ages of 10 and 17 years to play a series of games on a large multitouch tabletop. The games were built off of the elements of Collaboration Patterns (Passive Sharing, Active Sharing, Joint-Performance, Unrestricted Interaction). In order to move through the stages in Collaboration Patterns, the students had to complete certain tasks that required that they collaborate with each other. Upon reflection, researchers pointed out that the students were eager to interact with each other as they shared a common goal and even started to motivate each other with verbal praise.

All of the technologies presented here functioned as IT in their respective interventions. Each provided instruction in lieu of assistance, and none were meant to act as permanent supports. In terms of generalization and maintenance, while Chung et al. (2016) noted that online gaming should not replace the traditional therapist in CBT sessions, it is reasonable to infer that the technology could be used as a supplement to such therapy. Because maintenance and generalization were not examined as part of the research study, it is impossible to know for certain whether or not the skills were lost, but because of the initial success of the intervention, future studies are promising. Neither Mairena et al. (2019) nor Silva et al. (2014) looked at maintenance or generalization and, as the interventions were short in length, the researchers noted that longitudinal studies are needed.

Video Modeling

The next category of technology examined is video modeling (VM), which can be shown on an electronic device such as a phone or tablet. To use VM, a behavior or skill is recorded with a video recording device (such as a phone) and played back to the student for instruction. There are several types of VM, including video prompting, video self-modeling, and point-of-view video modeling (Hughes, et al., 2016). Each type of VBI has a specific purpose and prompts the student in a specific way. VBI provides instruction "that can be viewed across settings, including, classrooms, community, and vocational and field trip locations" (Hughes & Yakubova, 2016, p. 115), making it ideal when promoting generalization and maintenance. The following two studies both examine the implementation of video modeling and video self-modeling as ways to promote social skills in students with ASD.

Along with other social skills, students with ASD commonly struggle to give compliments, particularly when they are not prompted to do so (Macpherson et al., 2014). Macpherson et al. wanted to observe the compliment behaviors after using video modeling technology. Five elementary and middle school students with ASD participated in an after-school kickball game during which they were shown videos (on an iPad) of compliments being given. After viewing the video, the child was expected to give a compliment like the one in the video. Finally, after each child completed a set number of turns, the iPad was removed, and the game continued with the hope that the students would continue the compliment behavior. The results of the study indicated that the students did indeed continue using compliment behaviors after the iPad was removed, and the variation of their responses grew (for example, saying “You did it” instead of “Good job” as displayed in the video).

The second study was a single subject study implemented by teachers (special education and early childhood education) and paraprofessionals (Kabashi & Epstein, 2017). Researchers identified a preschool student with autism who lacked either the motivation or skills to initiate social interactions with others and proposed that video self-monitoring would improve his abilities. Video self-modeling is similar to video modeling except that, instead of viewing another person on the video, the student videos himself performing the skill and then watches it as a reminder of how to complete the skill

(Hughes & Yakubova, 2016). Typically, the teacher talks the student through the skill during the video recording and then she edits out her voice for the final product.

In this intervention, the teacher presented the recorded videos on an iPad to the student and, after viewing the videos, instructed the student to perform the social initiations that were exhibited in the videos (Kabashi & Epstein, 2017). If certain behaviors were not performed, the teacher would only show the segments of videos exhibiting those specific behaviors before allowing the student another opportunity. Results of the study revealed that the student quickly progressed in his abilities to approach and greet another student, which is a significant accomplishment considering that "greeting is usually a challenging skill for children with autism to acquire" (p. 118). The student also learned how to invite a friend to play, although, over time, the student began to grow bored with the play activities.

In both studies, as with gaming technology, it is clear that the VM was used as IT because of its temporary nature and instructional design. In the study by Macpherson et al. (2015), while the students were shown the video during the kickball game, they did not use it as an aid for communication. Similarly, in Kabashi and Epstein's (2017) study, the student with autism initiated conversation only after viewing or reviewing the self-modeled videos. Both studies also show promise in the areas of maintenance and generalization. Macpherson et al. did not specifically examine generalization patterns in their study, but they did conduct their intervention in a naturally-occurring social environment as opposed to a controlled instructional setting. This demonstrates the usability of the technology in daily life and the willingness of the students to use it during an activity they enjoy (in this case, kickball). Furthermore, the researchers noted that, because the children varied their compliments, they did not simply memorize the script. This is significant because it demonstrates that understanding of the skill was internalized and then applied in a personalized manner. Although maintenance of the skill over time was not studied, if the skill were to be practiced consistently, there is promise that maintenance could occur. Kabashi and Epstein explicitly looked at both generalization and maintenance in their study and found that in terms of generalization, the student could perform his initiation skills in a variety of settings and with different peers; he even began to increase his interactions. Three weeks after testing for generalization, the student was able to continue initiating interactions with his peers, thus demonstrating maintenance.

Social Robots

While some may think of robots as the fun toys children play with, these devices are capable of so much more than being used as a plaything. In a study by Warren et al. (2015), researchers wanted to examine the relationship between the use of a humanoid robot and increased joint attention among six young students with ASD (Warren et al., 2015). The robot, NAO, is a child-sized humanoid robot and capable of giving joint attention prompts. These prompts may be verbalizations, eye gazes, or pointing of arms or fingers. Different eye trackers and monitors were used in this study to follow the actions of the student so that robot controllers could direct the robot accordingly.

During this specific trial, the robot turned its attention to a random spot indicated by a target and prompted the student to attend to that point as well (Warren et al., 2015). The prompts gradually became more involved, moving from requiring only object-naming to name and pointing, for example. Overall, the children improved with each session and continually remained interested in the robot. Their responses were accurate, and all but one participant improved joint attention skills. When compared with an identical intervention using a human administrator in lieu of the humanoid robot, the children with ASD spent “27% more time” attending to the robot than the human, thus indicating increased interest in the robot and ability to maintain attention to the device (p. 3727).

The next study is rather unique in that it included three pairs of children: a pair of twins, a pair of siblings, and a pair of classmates (Taheri et al., 2017). All of the students in the study had been diagnosed with ASD. The researchers point out that the advantage of using twins and siblings in a study is the “control advantage” (p. 94). This refers to the fact that these children come from the same parents, eat the same food, and live in the same environment; these are often difficult factors to control in a study. The goal of the study was to look at the effects of the robot intervention across the pairs of students.

In the intervention, the researchers designed therapeutic games based on Applied Behavioral Analysis (ABA) that focused on imitation and motor skills, for example, joint attention and eye-contact (Taheri et al., 2017). The various sessions were structured so that the child and robot always interacted, but sometimes a parent, peer, or therapist was engaged as well. In this study, the robot served more as a positive reinforcement and model to the child. The student engaged in a number of activities such as playing a xylophone or pointing to objects and the robot gave verbal praise or attended to the object as well. Overall, the students enjoyed playing with the robots and even called them their friends. It is important to note that human-robot interactions are constructed based on the human-human interaction rules. Keeping in mind that effects among children at various points on the autism spectrum differ, the study revealed an increase in joint attention, better verbal communication, and a general decrease in autistic behaviors.

Another study, this one by Özcan et al. (2016), used "transitional wearable companions (TWCs) with autistic students" (p. 471). These devices are in the form of large stuffed animals that can be worn around the child's neck and that hang down the back of the child. They are soft, embedded robots that have the ability to vibrate, light up, and make sounds based on reactions detected from the child. These detections can be sensed by the child's blood pressure, anxiety level, heart rate, or an outside observer with access to the TWC's controls. Parents may control the device from their electronic device and can also receive signals when their child seems to become stressed.

Children with ASD typically do not initiate social interaction nor do they feel comfortable in social situations (Özcan et al., 2016). Because of this, these researchers plan to use TWCs to ease these children when they encountered social situations such as a transitional object would do (blanket, stuffed animal, etc.). The intervention, which has yet to take place, would involve comparing the TWC with other desired items and whether one is more effective than another. Although there is no data yet linked to this device, it has many promising features that could help fill emotional gaps for children within social situations.

In the studies discussed here, the robots functioned as both IT and AT. In Warren et al. (2015), because the robot was used to train students in joint attention skills, it is considered IT. Although a robot could be used long-term to guide a student in social situations, that is not the case in this example. Taheri et al. (2018) also used their robots in an IT capacity. Each intervention session consisted of different games that the students played with the robot to train them in various social skills. Finally, in Özcan et al. (2016), the TWCs were used as AT because they were implemented in real social settings and acted as aids to the students. The devices moved beyond the instructional capacity into the world of AT by providing ongoing support that was both practical and influential. Although none of the studies tested for maintainability or generalizability, Taheri et al. noted that human-robot interactions are modeled after human-human interactions, making them as realistic as possible. This is an important factor to consider in future studies that pursue generalization. Because the interaction is based on natural relationship standards, there is a better chance the students will generalize their skills to new environments. The TWCs in Özcan et al. are clearly generalizable and maintainable because they are present wherever the child goes. It is important to note, however, that the TWCs may not necessarily teach social skills that are generalizable and maintainable; they only provide support unless specifically used otherwise.

Wearable Assistive Technologies

Some students with ASD may find it especially difficult to learn and practice social skills through a device because the experience lacks a personal connection and experience with another human (Daniels et al., 2018). Wearable Assistive Technologies, also known as WATs, attempt to solve this dilemma. These are devices students wear during the social interaction and can serve several different purposes. Google Glass, in particular, showed much promise as a component in situations where WAT is appropriate.

Three of the most recent studies examining the feasibility and effectiveness of Google Glass in social skills training have all sought to promote positive interactions with another individual during conversation through both verbal and nonverbal means. A study by Daniels et al. (2018) examined how accurately 43 children (ages 6-17 years) identified emotions of another person on a computer screen while wearing Google Glass. Results revealed that the students did not find Google Glass overstimulating and, when given the opportunity to label emotions, the group of students with ASD performed at the same level of success as the control group of students without ASD. Sahin et al. (2018) examined the successor to Google Glass, called Glass, to see how interested users would be in using the device. The eight students with ASD involved in the study reported that, just as the students in the study by Daniels et al., they were not overstimulated by the glasses.

Kinsella et al. (2017), after noticing that many of the available forms of social skills intervention are typically expensive and limited because of their dependence on human services, examined how Google Glass could be used to prompt initiations and responses in communication for 15 students with ASD. They developed a software application named Holli that ran in conjunction with Google Glass. This program “listens” for verbalizations and “then provides various greetings for the [autistic student] to choose from” (p. 3). The student is then able to choose from one of the responses shown on Holli’s screen to use as a response. Holli kept up with the conversation to provide support for the student. In the trial, “the device was successfully able to detect, on average, 9/10 utterances” (p. 6) during each of the exchanges, although the program was not always able to detect the verbal tics or stutters of some of the students. Overall, Holli kept up with the conversations and the children generally enjoyed using the device.

Returning to the research questions, do the WAT devices discussed here function as AT or IT? In the case of Daniels et al., (2018), researchers used the device as a form of

IT in their research study because Google Glass provided different emotions on a screen as options for the children when they were trying to understand how another person was feeling. It is reasonable to infer that, after a training period with the WAT, the students would become familiar with the emotions and be able to identify them independently. In the study by Kinsella et al., (2017) however, the students used Google Glass in conjunction with Holi as AT because it was considered a "supplementary device" (p. 4) meant to assist with a practical skill. The Holi system provided the participants with aid during conversation by displaying options on the screen. Thus, it is clear that WAT may function as either AT or IT as it serves students. While none of the Google Glass studies tested generalizability or maintenance, the studies by Daniels et al. (2018) and Kinsella et al. (2017) did mention that these two features are often lacking in other types of social skills interventions.

Review of Research Questions

Now that the devices have been reviewed, the research questions are brought back into view and examined once more, taking all of the devices into consideration. The first question was: Could the devices used for social skills intervention in PreK-12 students with ASD function as either AT or IT? The answer to this question is both "yes" and "no." In the technology categories examined here, each category had at least one study in which the technology was used as IT, while only two categories (robots and WAT) contained technology that functioned as AT. The following table depicts the relationships between the various research studies examined, their approach, whether or not the skills were generalized or maintained, and the specific trend of the device.

Table 1

Relationships of Technologies to Approach, Social Skill, and Trend

	Technology Approach		Social Skill		Technology Trend					
Literature	AT	IT	Generalization	Maintenance	VR	AR	Games	Video Modeling	Social Robots	WAT
Chung et al. (2016)		✓	×	×			✓			
Daniels et al. (2018)		✓	×	×						✓
Kabashi & Epstein (2017)		✓	✯	✯				✓		
Kinsella et al. (2017)	✓		×	×						
Liu et al. (2017)		✓	×	×		✓				
Lorenzo et al. (2016)		✓	✷	×	✓					
Lorenzo et al. (2019)		✓	×	×		✓				
Macpherson et al. (2015)		✓	✷	×				✓		
Mairena et al. (2019)		✓	×	×			✓			
Özcan et al. (2016)	✓		✯	✯					✓	
Silva et al. (2015)		✓	×	×			✓			
Taheri et al. (2017)		✓	×	×					✓	
Warren et al. (2015)		✓	×	×					✓	
Zhao et al. (2018)		✓	×	×	✓					

Key ✓ = Meets Category ✯ = Tested and Achieved ✷ = Not Tested but Implied × = Not Tested

AT = Assistive Technology *IT = Instructional Technology* *VR = Virtual Reality* *AR = Augmented Reality*

WAT = Wearable Assistive Technology

Of the examined studies, why might IT be more prevalent than AT? First, it is important to consider the nature of the devices that functioned as both AT and IT. Robots, specifically the TWCs, are able to be worn and provide information within the naturally-occurring environment (Özcan et al., 2016). These are very specific yet important characteristics of AT; portability and usability in natural environments let the device be used to assist instead of to purely instruct. Similarly, WATs are portable in that they can be worn and are able to provide data on the environment to the user (Kinsella et al., 2017). When the Google Glass was used in conjunction with Holli, the user received assistance through response suggestions. On the other hand, Daniels et al. (2018) showed that WATs could also be used as IT when they implemented emotion recognition training with students. Had the students used the Google Glass in other environments for assistance in identifying emotions, this single intervention would have had a dual function. Thus, because by nature, AT seems to fit more specific criteria (e.g., portability) than IT, it is understandable that fewer devices would fit into its category. Another reason for the prevalence of IT could relate to social validity. If it is possible for a student to learn skills and then implement them without reliance on a device, this is preferable because it is generally more socially acceptable (Shepley et al., 2017). If researchers are searching for ways to teach social skills and it is more socially acceptable to not use a device, it is only reasonable that more studies would be conducted using devices as IT.

Maintenance and generalization were also examined here. Both the social robots and VR showed great promise in terms of generalization, while the mobile devices specifically tested for both generalization and maintenance. Lorenzo et al. (2016) and Zhao et al. (2018) commented that, in VR, they heard from teachers who noticed generalization after usage and spontaneous communication, respectively. The TWCs were conducive to generalization and maintenance because they assisted the student during social interactions (Özcan et al., 2016). Thus, as long as the student continued to use the device appropriately, the support would continue to be provided. One study of mobile devices (Kabashi & Epstein, 2017) looked specifically at maintenance and generalization as part of their study and they reported that, after receiving the intervention with the mobile application, the student generalized the learned skills to different environments and maintained the skills when observed again three weeks later.

Overall, however, because the majority of these studies primarily looked at feasibility or success within certain environments, they did not test for long-term effects. Some researchers did note, however, that longitudinal studies would be needed in the future to truly see whether the technology would be successful at promoting lasting and useful change (Mairena et al., 2019). Because only some of the studies reviewed here looked at or mentioned generalization and maintenance, it is inconclusive whether or not one piece of technology promotes these factors better than the others do.

Future Research Questions

From my analysis of the aforementioned studies, there are two knowledge gaps and related research questions that appear. The first gap relates to the relationship of both AT and IT with generalization and maintenance. Does whether a device functions as AT or IT have an effect on its ability to promote generalization and maintenance? This is an important consideration because, if one of the two classes of technology is more effective at promoting generalization and maintenance, then social skills instruction should primarily focus on that class of technology since the outcome is long-lasting.

The second gap focuses on the comparison of social skills instruction with technology to that without technology. Although this study has only examined instruction with technology, there are still many methods for teaching without the use of devices. The summary question, then, still remains whether or not one type of instruction is preferable over the other. Specifically, does technology promote better maintenance and generalization of social skills in PreK-12 students with ASD than traditional social skills interventions?

Conclusion

In this work, I have looked at the many possibilities that exist for PreK-12 autistic students when they are given the right piece of assistive or instructional technology. The spectrum of technology from which to choose is ever-expanding, so perhaps now more than ever is it important to ensure that effective devices are chosen so that the student has the best opportunity to succeed. When practitioners and parents examine these options, they must consider how the device functions, the role it plays, and whether or not it will promote both maintenance and generalization of skills with the student. When any of these factors are not taken into account, the device may not play the role it is expected to and the student may not progress. If these factors and the unique abilities of the student are considered, however, all parties involved have contributed to provide the student with the tools they need to confidently encounter a spectrum of social situations.

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