Tech-Aided Interventions for Vocational Skills in Adolescents and Young Adults with Autism Spectrum Disorder

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Abstract. Employment appears to be one of the greatest problems individuals with ASD have to deal with during their transition to adult life. In particular, unemployment or underemployment appears to be common among them, which suggests a gap in employment theory and practice focusing on the needs of this population. Tech-aided interventions appear to be promising since they can provide them opportunities to access competitive employment. The purpose of the current article is to examine the use of technology in interventions for adolescents and young adults with ASD in school, home, and community settings. In particular, it focused on the users of technology, the goals addressed, the type of technology employed, the contexts in which intervention practices were employed, and the outcomes for adolescents and young adults with ASD. In most of the studies, positive results were recorded and the importance of the work-related social skills was underlined. Technology appears to show potential for the enhancement of vocational skills of adolescents and young adults with ASD. Future research should focus on the improvement of work-related social skills and the skills needed for successful job seeking and an interview process. The maintenance and the generalization of the acquired skills should be examined too.

Keywords: Autism spectrum disorder, adolescents, young adults, vocational skills, work-related social skills, employment, technology

1. Introduction

Autism Spectrum Disorder (ASD) is a pervasive neurodevelopmental disorder that involves disrupted functioning in the areas of social skills, socialization, communication, and managing social relationships. In addition, it is characterized by repetitive and/or stereotyped behaviors and interests, and difficulties with planning and sequencing tasks [2]. Moreover, individuals with ASD exhibit difficulties in understanding the body language and the feelings of other people, and they process visual information more efficiently than verbal information [2].

Although ASD is usually diagnosed in childhood, it is a lifelong condition [2]. Most of the research had focused on young children, with little attention given to adolescents and young adults [15]. Individuals with ASD exhibit poor outcomes in many areas of adulthood, due to the challenges and the barriers they face throughout their life [21]. Recent estimates in the prevalence of ASD are approximately one in 54 individuals [31], whereas it was one in 59 [4]. This indicates that services and supports are needed for individuals with ASD, especially for adolescents and young adults. Since children with ASD grow up and become adolescents and young adults, they face several difficulties including social relationships with their peers, vocational rehabilitation, and entry into society. In particular, employment is thought to have a great impact on all people's life let alone individuals with ASD [37]. Previous researches indicate that individuals with ASD are less likely to be employed than their peers with typical development [18] since only 6-25% of individuals with ASD are employed [34]. Moreover, the employment rate of adults with ASD was significantly lower than adults with other disabilities [41]. 26% of the adults in the United States have some type of disability [12], and only 17.9% of them who are of working age are employed, down from 19.3% in 2019 [8].

Successful employment outcomes for individuals with ASD are influenced by a variety of internal and external factors [39]. The unique characteristics of each individual with ASD may have an impact on the employment outcomes. The IQ level, language ability, and various comorbid conditions may influence negatively the employment outcomes [20]. Their deficits in social skills such as difficulties in understanding facial expressions, body language, and social cues, in adjusting to new routines and changes, their persistence in repetitive behaviors. Chiang and colleagues (2013) found that secondary school leavers with ASD with a high level of social skills were more likely to be employed than those with low social skills. Even when individuals with ASD are employed, it's not unusual to lose their job because of poor social skills such as interrupting or terminating a conversation, incorrect use of language phrases, the inability to understand facial expressions, emotions, tone of voice, comprehending the social rules in the workplace environment [19]. The job-seeking process and the interview process are considered to be problematic. Individuals with ASD face many difficulties with how to look for a job, initiate job cont11act, and following-up once contact was made [33]. Even more, they find it difficult to fill in a job application, what type of information should be provided in the application, or what details should be included in the interview [33]. The interview continues to be one of the most common selection methods for a work position. Individuals with ASD may have difficulties in verbal and non-verbal communication, expressing themselves, being able to understand the body language of the interviewer, being distracted [30]. Education and family support are two factors that facilitated employment [20]. Chiang and colleagues (2013) found that

graduation from high school may affect employment to a higher degree than ASD characteristics (e.g., comorbid conditions, deficits in social skills). In addition, Migliore and colleagues (2012) found that post-secondary education may help this population to find and maintain a job. Moreover, adolescents and young adults who have received post-secondary education are reported to be employed in competitive settings at higher rates than their peers without post-secondary education [14]. The socioeconomic status of the family is an important factor in the employment outcomes since young adults with ASD with higher income are more likely to be employed [41]. Despite the importance of employment, Baldwin and colleagues (2014) recorded that 85% of the 130 participants with high-functioning ASD had post-secondary education, almost half of them were overqualified for their jobs, and only 6% of the participants worked in a managerial position.

There is a need to improve employment opportunities for adolescents and young adults with ASD, as this population continues to increase [41]. There is a lack of research on employment skill development and on-the-job strategies needed to promote the success of individuals with ASD [6]. During the last decades, several technology-based methods have been implemented in interventions with individuals with ASD, aimed at enhancing a wide range of skills [6, 40, 42]. Several reviews concerning ASD and technology have made contributions to the exploration of various aspects of this topic. Odom and colleagues (2015) underlined the use of technology in interventions and instruction for high school students with ASD in school, home, and community settings, and their impact on academics, adaptive behavior, challenging behavior, communication, independence, social competence, and vocational skills. Johnson and colleagues (2020) identified ways that human resource development professionals can foster skill development and promote a work environment that supports the success of employees with ASD. Given the impairments and the difficulties that individuals with ASD face and the need for training in vocational skills, it is of great importance to better understand the findings of technology research related specifically to the enhancement of the vocational skills for adolescents and young adults with ASD. The present review examined studies that included adolescents and young adults with ASD and was focused on the development of vocational skills in this population. The review was based on the following research questions: 1) What were the characteristics of the participants?, 2) What was the most popular type of technology used?, 3) What was the most popular type of intervention implemented?, 4) What were the intervention outcomes for adolescents and young adults with ASD?

2. Methods

The review focused on interventions for adolescents and young adults with ASD. Each of the included studies in the current review met the predetermined criteria; was analyzed and summarized in terms of skills, participants, type of technology, type of intervention, setting, intervention outcomes, generalization, and maintenance.

2.1 Research procedure

Five electronic databases were searched for primary studies for this review (PubMed, Education Resources Information Centre; ERIC, Scopus, Science Direct, and Scholar Google). The included studies were written in English, appeared in peer-reviewed journals, and were limited by publication date. The keywords used were: ASD, adolescents, young adults, technology, vocational skills, work-related social skills, employment. The researchers combined ASD and technology and adolescents and/or young adults and vocational skills or work-related social skills or employment. This search resulted in a total of 277 studies, which, after the removal of duplicates were reduced to 260. The researchers read the titles and the abstracts to exclude studies that did not include experimental results of intervention programs, and/or included participants of different ages and/or other disabilities, not including ASD. The remaining studies were independently screened by the researchers for adherence to the inclusion and exclusion criteria. An ancestral search was conducted using the reference list of the studies that met the inclusion criteria, and the “cited in” feature in Scholar Google. No additional articles were identified. A hand search in peer-reviewed articles was performed, which led to no additional articles. The included studies were identified to be 18. Interrater agreement (IRA) during the electronic database search, hand and ancestral search, and the screening were fulfilled by having the researchers separately search and screen the articles. The overall IRA was 90%. In case of disagreement, the researchers discussed and searched again whether the article met the inclusion criteria.

2.2 Inclusion and exclusion criteria

The studies had to meet the following inclusion criteria: a) the studies focused on technology-aided interventions for adolescents and young adults with ASD; b) the participants were aged between 12 and 25 years and had been diagnosed with ASD; c) the studies were published between 2010 and 2021 (the year 2010 was chosen because studies older than 10-12 years might refer to technology considered partially obsolete); d) the studies were written in English. Studies were excluded from the review if they: a) were non-experimental; b) did not include at least one participant aged 12 to 25 years. Studies that targeted adolescents and young adults aged 25 years or in which the mean age of the participants was <25 years at the start of the intervention were included. Grey literature was excluded (e.g., dissertations, chapters, review, etc). To determine whether a study met the inclusion criteria, the researchers searched and evaluated the studies independently. The selected studies were compared for reliability, which was calculated using percent agreement on the articles that each author identified as meeting the inclusion criteria. Any disagreements between the authors were discussed until they agreed. The obtained IRA was 90%.

2.3 Coding procedure

The following coding categories were used: a) participant' characteristics (number, age, gender, and diagnosis), b) skills targeted in the study, c) type of technology used (laptop, videotape, tablet, etc.), d) type of intervention implemented (VM, VP, VR, etc.), e) settings (e.g., classroom, home, controlled research environment, etc.), f) outcomes, g) generalization, h) maintenance. The researchers reviewed the 18 studies to determine whether each of them met the coding categories. The extracted data are shown in Tables 1 and 2. The researchers compared the coding results, and the IRA was 90%.

3. Results

18 studies met the inclusion criteria and were submitted to the coding procedure. Table 1 provides a summary of the studies in terms of a) participant's characteristics, b) type of technology used, c) type of intervention implemented, d) settings (e.g., classroom, home, controlled research environment), while other details, including outcomes, generalization, and maintenance are presented in Table 2.

3.1 Participant characteristics

A total of 380 participants were included in the interventions across the 18 studies. 225 of them were male, whereas 59 were female. In one study [22] the gender of the participants was not reported. Most of the participants were diagnosed with ASD, but some participants were reported as having two or more co-occurring diagnoses (i.e., complex communication needs; CCN, Asperger's Syndrom; AS, obsessive-compulsive disorder; OCD, attention deficit hyperactivity disorder; ADHD, Tourette Syndrome; TS, intellectual disability; ID, social anxiety, selective mutism, epilepsy).

3.2 Targeted skills

The 18 studies were examined across a variety of vocational skills, which targeted to increase employment outcomes for individuals with ASD. These skills were organized into two broad categories: on-the-job skills (e.g., paper shredding, packing material, weeding, etc.) and more generic skills (e.g., job interview skills, social vocational skills, career decisions, etc.). Ten out of 18 studies targeted generic skills, which included work performance [17], reducing personal support needs [17], interview skills [9, 22, 26, 44], social skills [7, 10, 24], self-efficacy [27, 28]. Eight of the studies targeted specifically on the job skills included entertaining customers [1], checking in books, making dye-cut prints, paper shredding [3], checking materials, replacing defective items [9], gardening [16], cleaning, vacuuming, recycling [25], coding, testing software [29], telephone skills [36], cleaning dishes, sorting mail, stocking milk [43].

3.3 Type of technology and intervention

The current review focused on identifying the different applications of the technology used to teach vocational skills to adolescents and young adults with ASD. Table 1 indicates the range of the technological devices used in the interventions. Seven studies utilized multiple technologies (i.e., camera and computer; [7], camera and iPod; [16, 43], iPhone and Cardboard VR viewer; [27], iPads and HP Slates; [28], laptop, iPhone and camera; [36], television, e-books, microphones, and headsets; [44]) in conjunction with VM, VR, or VP or combination of them. Two studies utilized tablets to deliver video VSDs [3] and VM and VP [9]. Two studies employed robotics (Nao; [24], Actroid-F; [26]). The application of the iPod was employed for three studies [10, 17, 25] to deliver cue systems, VM, and prompts or written instructions.

3.4 Outcomes

The outcomes of the intervention programs for adolescents and young adults with ASD are presented in Table 2. All the studies in the review reported positive results. Upon the introduction of the tech-aided intervention, most of the

TABLE 1. Summary of the studies using tech-aided interventions to enhance vocational skills: participant characteristics, targeted skills, type of technology and intervention, settings.

Studies	Participant characteristics (age, gender, diagnosis)	Targeted skills	Type of technology	Type of intervention	Settings
Allen et al. (2010)	3M, ASD, 17-22 years	Teaching skills necessary to entertain customers and promote products in a retail setting while wearing a WalkAround® costume	WalkAround costumes	VM, POV VM	Scripted and naturalistic settings (i.e., warehouse store)
Babb et al. (2018)	1 M, ASD & CCN, 18years	Vocational (checking in books, putting books away, making dye-cut prints, paper shredding)	Tablet-based app	Video VSDs (AAC)	Vocational (rural elementary school library)
Bross et al. (2020)	4M, 1F, ASD, PDD-NOS 18-26 years	Social-Vocational (customer service skills, verbalization of greeting, service, and closing phrases appropriate for customer interactions)	Digital camera with video recording capability, computer	VM	Community employment settings (i.e., ticket taker at the amusement park, working at a kitchen area with an adjacent loading dock, working the cash register at a movie theatre, delivering mail and newspaper at a nursing home)
Burke et al. (2010)	Study 1: 3M, 20-27 years, ASD, AS Study 2: 3M, 18-20 years, ASD, AS, OCD, ADHD, TS	Social-vocational	iPhone app	Study 1: Training DVD, training script, Performance cue system (PCS), home practice logs Study 2: PCS	Large open area where mascots are produced
Burke et al. (2013)	4M, AS, OCD, ADHD, TS, VI 19-28 years	Vocational (i.e, checking to make sure materials were in working order, replacing defective items, packing materials in a container, entering information into a computer, and attaching a label to a container)	Computer tablet, *VideoTote* software	VM, VP	A manufacturing and shipping warehouse
Burke et al. (2020)	110M, 40F, ASD, ADHD, ID	Job interview skills, self-efficacy, career decisions	Laptop or computer, monitor, speakers, microphone, wireless mouse, and keyboard	ViTA	NM
English et al. (2017)	3M, AS, social anxiety, selective mutism, epilepsy 18-23 years	Vocational gardening (i.e., weeding, picking, planting, quality control, bed marking, hoeing, labeling)	Camera, iPad 4, iPod	VM, VP, audio narrations	A not-for-profit social enterprise that grew edible flowers for sale, Garden
Gentry et al. (2014)	"Now group": 24M, 2F, MA= 25 years, ASD "Delayed" group: 18M, 6F, MA= 22.9 years, ASD	Vocational (improvement of work performance, reduction of personal support needs on the job)	Apple iPod Touch PDA		Job setting (e.g., grocery stock, restaurant food preparation, restaurant bus service, pharmacy aide, car wash, pet shop, rental car, library)
Humm et al. (2014)	26 ASD 37 schizophrenia/other 33 PTSD	Vocational (teach, reinforce, refresh, practice job interviews skills on computers in a stress-free environment)	Computer-based program Job interview training	VR role-play	NM

			system with Molly		
Kaboski et al. (2014)	8M ASD, 8M TD 12-17 years	Social anxiety, social-vocational (programming voice recognition and face tracking, strategies on how to listen to others and understand them better)	Robotics, NAO	Each participant pair worked on a computer and programmed movements using Choregraphe, programming software developed for NAO. They presented their final project. The main rules were that they had to program the robot to be social with the crowd, and demonstrate each of the programming skills they have learned.	Summer robotic camp held at a lab known in the community for ASD research
Kellems & Morningstar (2012)	4M ASD 20-22 years	Vocational (e.g., cleaning, vacuuming, emptying the garbage, recycling)	Apple video iPod	VM, written instructions (each step was introduced with a 5s written description consisting of black text on a white background)	Each participant's place of employment
Kumazaki et al. (2017)	Android robot-mediated group: 6M, 1F ASD M.A.=23.1 years Independent study group: 6M, 2F ASD M.A.= 23.4 years	Vocational (job interview skills)	Android robot, Acrtroid-F	Mock job interview training with a human interviewer or android robot, or independent study (i.e., using a textbook for a job interview)	NM
Kuper et al. (2019)	8M, 2F ASD 19-42 years	Self-efficacy	Multimedia training stimuli	Video, VR media stimuli, instructions in text form, verbal instructions	Participants' home, conference room, private library rooms at the university they attended
Laarhoven et al. (2018)	2M, 2F ASD 15-18years	Vocational (e.g., independent correct response, problem-solving behavior, independent completion of vocational tasks)	Universally-designed prompting system presented on iPads and HP Slates (the Go Talk Now app, PowerPoint 2010)	Two treatment conditions were introduced in a rapidly alternating fashion with the order of presentation being randomized to compare the effects of the two interventions on the same skill. Researchers measured the percentage of correct responses, the percentage of media options selected by participants, and the percentage of decision points correctly selected by participants across baseline and intervention phases.	Faculty conference room at their high school
Lee et al. (2019)	5M ASD 15-18 years	Vocational-ICT-related skills (e.g., coding, testing software, quality control, beta testing, digital design of applications), social skills	Grounded theory approach	AASQA CoderDojo program	Different host organizations (e.g., financial institutions, university information technology services, and technology solutions companies)
Rausa et al. (2015)	1M, ASD, 23 years	Job-related telephone skills (listening and responding to orders and complaints, professional speech)	Laptop, Apple iPhone-5, camera	VM	Large commercial flower and plant farm
Walsh et al. (2019)	2M, 1F ASD &ID 20-21 years	Vocational (e.g., identifying jobs that match individual preferences and	Technology-based pre-work assessment	VM was used to depict the different employment options available to the	Supermarket, sportswear store, candy store, training

		strengths; cleaning dishes, letter folding and sorting mail, stocking milk on shelves, sales assistant, tidying and organizing display clothes)	(e.g., video camera, iPad)	participants, MyPref app was used to assess participants' job preferences	room, cafeteria,
Ward & Esposito (2018)	10M, 2F, ASD 18-22 years	Job interview skills (i.e., job application, getting ready, the interview), self-confidence, self-efficacy	Television, google chrome books, headsets, microphones	VR-JIT program with Molly Porter	Adult Transition Programs (ATP) school setting

Note AS= Asperger's syndrome, ADHD= attention deficit hyperactivity disorder, AAC=augmentative and alternative communication, ASD=autism spectrum disorder, CCN=complex communication needs, BST= behavioral skills training, F=female, ID=intellectual disability, M=male, M.A.= mean age, NM= not mentioned, OCD= obsessive-compulsive syndrome, PCS= performance cue system, PDD-NOS= pervasive developmental disorder-not otherwise specified, POV VM=point-of-view video modeling, TS= Tourette Syndrome, TD= typically developing, VM= video modeling, VSDs=videos with integrated visual scene displays, ViTA= virtual interactive training agents, VI= visual impairment, VR= virtual reality, VR-JIT program=virtual reality job interview training program

TABLE 2. Summary of the studies using tech-aided interventions to enhance vocational skills: outcomes, generalization, maintenance.
Note BST= behavioral skills training, PCS= performance cue system, VFB= video feedback, VM= video modeling, VP= video prompting,

Studies	Outcomes	Generalization	Maintenance
Allen et al. (2010)	Upon the introduction of VM, all of the participants were able to perform the skills. None of them required additional prompting or arbitrary reinforcement components to meet the criterion. These skills were maintained by two of the participants at high levels at a 1-month follow-up. Finally, all three of the participants generalized the skills to a novel work setting several months later, performing at acceptable levels in an actual work environment.	Yes (3 months after the intervention each participant was asked to generalize the acquired skills to a novel, untrained costume in an untrained setting)	Yes (one month after the intervention, at the warehouse store)
Babb et al. (2018)	Using video VSDs supported the participant in learning to complete vocational tasks independently within a vocational setting and to communicate with others at these times. The participant needed a small number of sessions to demonstrate a treatment effect and achieve mastery. Upon the introduction of the app changes in performance were observed.	Yes (paper shredding)	Yes
Bross et al. (2020)	After participants watched the videos, they increased their customer service skills and improved their quality of interactions with customers. In addition, all participants improved the timing of delivery phrases after receiving the VM intervention.	Yes	Yes (2 and 4 weeks following VM intervention cessation; no videos played during the maintenance probes)
Burke et al. (2010)	Study 1: With the introduction of BST the three participants showed small performance improvements, whereas upon the introduction of PCS showed immediate improvement. Two out of the three participants maintained performance at the maintenance probe and performed at or near criterion during the generalization assembly. Study 2: With the introduction of PCS, two participants showed immediate improvement to criterion level performance. Both the participants maintained performances at follow-up and performed at criterion during the actual generalization assembly. The third participant showed immediate but unsustained improvement with PCS so the BST program was introduced and the two training programs together produced immediate criterion level performance.	Yes (1 month after the conclusion of treatment)	Yes (study 1:same place in front of an audience of local elementary students)
Burke et al.	The combination of VM during pre-employment training and on-the-job VP was helpful for the participants when	No	No

(2013)	completing a complex shipping task. The intervention resulted in improvement in on-the-job performance, but one participant was not able to produce consistent criterion-level performance.		
Burke et al. (2020)	The participants demonstrated increased skill at making appropriate introductory and closing statements, communicating personal and professional strengths, identifying examples of previous situations or behaviors related to the position applied for, and demonstrating an understanding of the day-to-day practicalities of life on the job. Self-efficacy domains (i.e., strengths, career decisions) showed improvement too.	No	No
English et al. (2017)	The use of VM with VFB led to improvements across skills for two of the participants. The third one required VP for successful acquisition.	Yes (across personnel and settings for two of the participants)	Yes (data were collected at various points between 1 and 6 weeks after intervention)
Gentry et al. (2014)	Participants who received PDA training at the beginning of their job placement required fewer hours of job coaching support than those who had not received the intervention. The significant difference in hours of job coaching support persisted during the subsequent 12 weeks, in which both groups used a PDA. With a reduction in job coaching hours for participants who were trained to use the PDA immediately upon starting work, it is possible to estimate the cost-effectiveness of the intervention.	No	Yes (information was collected from both groups for an additional 12 weeks)
Hum et al. (2014)	The program showed a moderate to large effect on improving job interview skills through live role-play interviews and increasing self-perceptions of confidence, comfort, and readiness for job interviews. There were not any significant differences between diagnostic groups. The follow-up research showed that more than half of the participants (9 out of 16) randomly assigned to the Molly group had found work.	No	Yes (conducted 20 weeks post-intervention.
Kaboski et al. (2014)	The participants learned robotic facts, programmed an interactive robot, and learned career skills. The ASD group showed an increase in robotics knowledge, yet neither group showed a significant increase in social skills.	No	No
Kellems & Morningstar (2012)	Upon the use of the iPod, the participants showed immediate and substantial gains in the percentage of steps completed correctly. In addition, they were able to use the video iPod independently and they demonstrated maintenance in the acquired skills.	No	Yes (the participants maintained their performance on their first two vocational skills up to 30 days)
Kumazaki et al. (2017)	After the android-mediated training sessions, the participants showed improved self-confidence and demonstrated lower levels of salivary cortisol compared to the control condition group.	No	No
Kuper et al. (2019)	Participants who received training through MTS showed a significant increase in their perceived self-efficacy to perform the task of wiring an electrical outlet	No	No
Laarhoven et al. (2018)	Both devices resulted in immediate and substantial increases in independent responses for three of the four participants. All participants performed better with their preferred device and all self-faded reliance on instructional prompts as skill acquisition increased.	No	No
Lee et al. (2019)	Adolescents with ASD gained practical insights into the operations and expectations of the workplace and employment. They were enthusiastic and pleased that they worked on real data. The program helped adolescents and their parents to see their potential and strengths and improve their confidence. There were communication challenges with the participants with ASD, which did not impact their work and good relationships were maintained.	No	No
Rausa et al. (2015)	The use of VM intervention led to immediate improvements in listening and responding to orders and complaints, and in the participants' professional skills.	No	Yes (all skills increases were maintained at 6-week follow-up)
Walsh et al. (2019)	All three participants performed higher (i.e., completed the elements of the task analysis) in the high-preference job conditions when compared to the low-preference job conditions. In addition, the results indicated that the high-preference job conditions produced higher levels of job performance irrespective of skill match.	No	No
Ward & Esposito (2018)	Significantly improved job interview skills and self-reported confidence levels for the participants were evidenced for the participants. In addition, improved self-efficacy beliefs related to handling novel difficult situations were reported.	No	No

participants required fewer hours of job coaching [17], improved their interview skills and self-confidence [11, 26, 44]. In the study of Humm and colleagues (2014) the program showed a moderate to large effect on improving job interview skills live role-play interviews and increasing self-perceptions of confidence, comfort, and readiness for job interviews. In addition, there were not any significant differences by diagnostic groups (i.e., ASD, schizophrenia/other, PTSD). During the implementation of the tech-aided interventions, the participants showed improvement in social skills, (i.e. increased service skills, improved the quality of interactions with customers and the time of delivery phrases; Bross et al., 2020, improved their performance; Burke et al., 2010), whereas in one study contrary to the researchers' prediction the ASD group did not show a significant increase in social skills [24]. In the remaining studies, participants who received the tech-aided intervention showed a significant increase in their perceived self-efficacy to perform the targeted task [27, 28]. Moreover, in the study of Laarhoven and colleagues (2018) all participants performed better with their preferred device and all self-faded reliance on instructional prompts as skill acquisition increased. Other studies reported improvement in various on the job skills requiring no additional prompting to meet the criterion [1], needing a small number of sessions or percentage of steps to demonstrate a treatment effect and achieve mastery [3, 25], requiring one or two training programs [9] or a different type of intervention to produce criterion level performance (i.e., VM or VP; English et al., 2017), gaining expectations of the workplace and seeing their potential and strengths and improving their confidence [29, 36]. The results of one study showed that the participants performed higher in the high-preference job conditions when compared to low-preference job conditions. In addition, the results indicated that the high-preference job conditions produced higher levels of job performance irrespective of skill match [43].

3.5 Settings

The majority of the studies took place in the community or real workplaces. A small number of studies (three out of 18) occurred in the home or a school setting. Three studies did not mention the setting at all.

3.6 Maintenance/Generalization

Five studies conducted both maintenance and generalization probes [1, 3, 7, 10, 16], while four studies conducted only maintenance probes [17, 22, 25, 36]. The remaining studies did not conduct a generalization and/or maintenance phase at all.

4. Discussion

The main aim of the review was to describe the studies and evaluate their main results related to the effectiveness of the implementation of technology in interventions for adolescents and young adults with ASD. 18 research papers were identified and analyzed. All of them were published since 2010 and they included participants in the age range 12-15 years at enrollment. Overall the results indicate that technology-aided interventions have been useful in teaching on the job and generic vocational skills to adolescents and young adults with ASD and improving performance in a real work environment. All 18 studies included at least one participant with ASD aged 12 to 25 years or the mean age of the participants was <25 years at the start of the intervention. The majority of the interventions were conducted for ASD; five studies included participants with Asperger's Syndrome, obsessive-compulsive syndrome, attention deficit hyperactivity disorder, Tourette Syndrome, visual impairment, social anxiety, selective mutism, epilepsy, schizophrenia. One study included a TD group for comparison; another one included three distinct groups (ASD, schizophrenia and other serious mental illnesses, veterans with post-traumatic stress disorder), two included a tech-mediated and a non-tech-mediated group or a "now group" (i.e., received the PDA training upon starting work) and a "delayed" group. The study participants were mainly male, which should be taken into consideration since it suggests that female is somewhat under-represented in these studies. In addition, the review showed that researchers employed a range of different applications of technology with tablets, computers, cameras, iPads, and iPods or a combination of them, which were most commonly used to deliver VM, VP, VR, or a combination of them. In addition to this, the use of technology in autism interventions has been expanded at a rapid rate within the last decade. Technology-aided interventions have been used to teach a range of vocational skills to adolescents and young adults with ASD. The skills targeted to increase vocational outcomes for individuals with ASD described in the review can be categorized according to specific on the job skills (e.g., paper shredding, packing material, weeding, etc.) and more generic skills (e.g., job interview skills, social vocational skills, career decisions). For adolescents and young adults with ASD leaving school, learning specific work-related skills seems to be very important. Yet, interventions should not focus solely on specific on-the-job skills, but the researchers should pay attention to work-related social skills that will foster a positive work experience. Social and communication skills (i.e., building and maintaining dialogue, understanding what others say, listening to the thoughts and the feelings of others) are very important in everyday life. As adolescents and young adults with ASD grow older, become more conscious of their social deficits, which may lead to limited social opportunities. Since the employment rate of this population is quite low, there is a need for support and identification of tools, which could help them to find and maintain employment. The included studies focused on job interview skills, which are of great importance since the interview is still the most common way of finding a job. Yet it appears to be difficult for individuals with ASD because they lack good verbal and/or nonverbal communication skills. Generalized outcomes that can be applied to the everyday real workplace are important aims of vocational interventions. However, only half of the

included studies conducted generalization and/or maintenance probes. These findings highlight that generalized and follow-up outcomes were underreported in the studies.

5. Limitations and Suggestions

This review has several limitations. It included only articles written in English and published in peer-reviewed journals. Grey literature was excluded. The keyword "technology" was the only technology-related term used, which may have narrowed the number of studies. In addition, the research procedure and the inclusion and exclusion criteria may have led to missing articles.

Social skills, one of the main impairments in individuals with ASD, were targeted in the interventions. Communication skills, building and maintaining dialogue, understanding what others say, listening to the thoughts and feelings of others are important in everyday life. Social demands become increasingly complex with maturation. As adolescents and young adults with ASD grow older, peer groups become more popular. Moreover, they become more conscious of their social deficits, which limit them from social relationships. In particular, work-related social skills are of great importance too. Students with high social skills are more likely to participate in employment compared to those with low social skills [13]. Furthermore, individuals with ASD, who have poor social skills including terminating inappropriately or interrupting conversations, lack of spontaneous language, incorrect use of language phrases, find it difficult to gain and maintain employment. High unemployment rates and high economic costs related to the disorder indicate the great need for further exploration of interventions that teach vocational skills. In particular, technology seems to be able to enhance on the job and generic work-related skills.

References

* Indicates intervention studies included in the review of the literature

1. * K. D. Allen, D. P. Wallace, D. J. Greene, S. L. Bowen, Burke, R. V. Community-Based Vocational Instruction Using Videotaped Modeling for Young Adults With Autism Spectrum Disorders Performing in Air-Inflated Mascots. Focus on Autism and Other Developmental Disabilities, **25**, 3, 186–192 (2010).

2. American Psychiatric Association (APA). Diagnostic and Statistical Manual of Mental Disorders (5th ed.). (2013).

*3. S. Babb, J. Gormley, D. McNaughton, & J. Light, Enhancing Independent Participation Within Vocational Activities for an Adolescent With ASD Using AAC Video Visual Scene Displays. Journal of Special Education Technology, **34**, 2, 120-132 (2019).

4. J. Baio, L. Wiggins, D. L. Christensen, M. J. Maenner, J. Daniels, Z. Warren, M. Kurzius-Spencer, W. Zahorodny, C. R. Rosenberg, T. White, M. S. Durkin, P. Imm, L. Nikolaou, Prevalence of Autism Spectrum Disorder among Children Aged 8 Years—Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2014. MMWR. Surveillance Summaries, **67**, 6, 1–23 (2018).

5. S. Baldwin, D. Costley, A. Warren, Employment activities and experiences of adults with high-functioning autism and Asperger's disorder. Journal of Autism and Developmental Disorders, 1–10 (2014).

6. K. D. Bennett, C. Dukes, Employment instruction for secondary students with autism spectrum disorder: a systematic review of the literature. Education and Training in Autism and Developmental Disabilities, **48**, 1, 67–75 (2013).

* 7. L. A. Bross, J. C. Travers, H. P. Wills, J. M. Huffman, E. K. Watson, M. E. Morningstar, & B. A. Boyd, Effects of Video Modeling for Young Adults With Autism in Community Employment Settings. Career Development and Transition for Exceptional Individuals, **43**, 4, 209–225 (2020).

8. Bureau of Labor Statistics. Persons with a disability: Labor force characteristics (2021).

* 9. R. V. Burke, K. D. Allen, M. R. Howard, D. Downey, M. G., Matz, S. L. Bowen, Tablet-based video modeling and prompting in the workplace for individuals with autism. Journal of Vocational Rehabilitation, **38**, 1–14 (2013).

* 10. R. V. Burke, M. N. Andersen, S. L. Bowen, M. R. Howard, K. D. Allen, Evaluation of two instruction methods to increase employment options for young adults with autism spectrum disorders. Research in Developmental Disabilities, **31**, 6, 1223-1233 (2010).

* 11. S. L. Burke, T. Li, A. Grudzien, S. Garcia, Brief Report: Improving Employment Interview Self-efficacy Among Adults with Autism and Other Developmental Disabilities Using Virtual Interactive Training Agents (ViTA). Journal of Autism and Developmental Disorders, **51**, 2, 741-748 (2020).

12. Centers for Disease Control and Prevention. Disability impacts all of us. (2019)

13. H. Chiang, Y. K. Cheung, H. Li, L. Y. Tsai, Factors associated with participation in employment for high school leavers with autism. Journal of Autism and Developmental Disorders, **43**, 8, 1832–1842 (2013).

14. R. E. Cimera, C. A. Thoma, H. N. Whittenburg, A. N. Ruhl, Is getting a post-secondary education a good investment for supported employees with intellectual disability and taxpayers? Inclusion, **6**, 97-109 (2018).

15. T. L. Edwards, E. E. Watkins, A. D. Lotfizadeh, A. Poling, Intervention research to benefit people with autism: How old are the participants? Research in Autism Spectrum Disorders, **6**, 3, 996-99 (2012).

* 16. D. L. English, S. Gounden, R. E. Dagher, S. F. Chan, B. E. Furlonger, A. Anderson, D. W. Moore, Effects of video modeling with video feedback on vocational skills of adults with autism spectrum disorder. Developmental Neurorehabilitation, **20**, 511–524 (2017).

* 17. T. Gentry, R. Kriner, A. Sima, J. McDonough, P. Wehman, Reducing the Need for Personal Supports Among Workers with Autism Using an iPod Touch as an Assistive Technology: Delayed Randomized Control Trial. Journal of Autism and Developmental Disorders, **45**, 3, 669-684 (2014).

18. D. Hedley, R. Cai, M. Uljarevic, M. Wilmot, J. R. Spoor, A. Richdale, C. Dissanayake, Transition to work: Perspectives from the autism spectrum, Autism, **22**, 5, 528-541 (2018).

19. D. Hendricks, Employment and adults with autism spectrum disorders: challenges and strategies for success. Journal of Vocational Rehabilitation, **32**, 2, 125-34 (2010).

20. A. Holwerda, J. J. L. van der Klink, J. W. Groothoff, S. Brouwer, Predictors for work participation in individuals with an Autism spectrum disorder: a systematic review, Journal of Occupation Rehabilitation, **22**, 3, 333-52 (2012).

21. P. Howlin, Outcome in adult life for abler individuals with autism or Asperger syndrome. Autism, **4**, 63–83 (2000).

* 22. L. B. Humm, D. Olsen, M. Bell, M. Fleming, M. Smith, Simulated Job Interview Improves Skills for Adults with Serious Mental Illnesses. Studies in Health Technology and Informatics, **199**, 50-4 (2014).

23. K.R. Johnson, D. Ennis-Cole, M. Bonhamgregory, Workplace Success Strategies for Employees With Autism Spectrum Disorder: A New Frontier for Human Resource Development, Human Resource Development Review, **19**, 2, 122-51 (2020)

* 24. J. R. Kaboski, J. J. Diehl, J. Beriont, C. R. Crowell, M. Villano, K. Wier, K. Tang, Brief Report: A Pilot Summer Robotics Camp to Reduce Social Anxiety and Improve Social/Vocational Skills in Adolescents with ASD. Journal of Autism and Developmental Disorders, **45**, 12, 3862-9 (2014).

* 25. R. O. Kellems, M. E. Morningstar, Using Video Modeling Delivered Through iPods to Teach Vocational Tasks to Young Adults With Autism Spectrum Disorders. Career Development and Transition for Exceptional Individuals, **35**, 3, 155–167 (2012).

* 26. H. Kumazaki, Z. Warren, B. A. Corbett, Y. Yoshikawa, Y. Matsumoto, H. Higashida, T. Yuhi, T. Ikeda, H. Ishiguro, M. Kikuchi, Android Robot-Mediated Mock Job Interview Sessions for Young Adults with Autism Spectrum Disorder: A Pilot Study. Frontiers in Psychiatry, **8**, 169 (2017).

* 27. G. E. Kuper, K. Ksobiech, J. Wickert, F. Leighton, E. Frederick, An Exploratory Analysis of Increasing Self-Efficacy of Adults with Autism Spectrum Disorder Through the Use of Multimedia Training Stimuli. Cyberpsychology, Behavior, and Social Networking, **23**, 1, 34-40 (2019).

* 28. T. V. Laarhoven, A. Carreon, W. Bonneau, A. Lagerhausen, Comparing Mobile Technologies for Teaching Vocational Skills to Individuals with Autism Spectrum Disorders and/or Intellectual Disabilities Using Universally-Designed Prompting Systems. Journal of Autism and Developmental Disorders, **48**, 7, 2516-2529 (2018).

* 29. E. A. L. Lee, M. H. Black, E. Tan, T. Falkmer, S. Girdler, "I'm Destined to Ace This": Work Experience Placement During High School for Individuals with Autism Spectrum Disorder. Journal of Autism and Developmental Disorders, **49**, 3089–3101 (2019).

30. B. López, L. Keenan, Barriers to employment in autism: future challenges to implementing the Adult Autism Strategy. Autism Research Network. (2014).

31. M. J. Maenner, K. A. Shaw, J. Baio, A. Washington, M. Patrick, M. DiRienzo, D. I. Christensen, L. D. Wiggings, S. Pettygrove, J. G. Andrews, M. Lopez, A. Hudson, T. Baroud, Y. Schwenk, T. White, C. R. Rosenberg, L. C. Lee, R. A. Harrington, M. Huston,... P. M. Dietz, Prevalence of Autism Spectrum Disorder Among Children Aged 8 Years— Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2016. MMWR. Surveillance Summaries, **69**, 4, 1–12 (2020).

32. A. Migliore, J. Timmons, J. Butterworth, J. Lugas, Predictors of employment and postsecondary education of youth with autism. Rehabilitation Counseling Bulletin, **55**, 3, 176–184 (2012).

33. E. Muller, A. Schuler, B. A. Burton, G. B. Yates, Meeting the vocational support needs of individuals with Asperger syndrome and other autism spectrum disabilities. Journal of Vocational Rehabilitation, **18**, 3, 163-75 (2003).

34. D. B. Nicholas, M. Attridge, L. Zwaigenbaum, M. Clarke, Vocational support approaches in autism spectrum disorder: A synthesis review of the literature. Autism, **19**, 2, 235–245 (2015).

35. S. L. Odom, J. L. Thompson, S. Hedges, B. A. Boyd, J. R. Dykstra, M. A. Duda, K. L. Szidon, L. E. Smith, A. Bord, Technology-Aided Interventions and Instruction for Adolescents with Autism Spectrum Disorder. Journal of Autism and Developmental Disorders, **45**, 12, 3805-3819 (2015).

* 36. V. Rausa, D. W., Moore, A. Anderson, Use of video modeling to teach complex and meaningful job skills to an adult with autism spectrum disorder. Developmental Neurorehabilitation, (2015).

37. A. M. Roux, P. T. Shattuck, B. P. Cooper, K. A. Anderson, M. Wagner, S. C. Narendorf, Postsecondary employment experiences among young adults with an autism spectrum disorder. Journal of the American Academy of Child and Adolescent Psychiatry, **52**, 9, 931–939 (2013).

38. B. Reichow, Development, procedures, and application of the evaluative method for determining evidence-based practices in autism. In B. Reichow, P. Doehring, D. V. Cicchetti, F. R. Volkmar (Eds), Evidence-based practices and treatments for children with autism (pp. 25–39). New York: Springer (2011).

39. K. Sarri, The Challenges of Vocational Training for Individuals with Autism Spectrum Disorder. In C. K. Syriopoulou-Delli, R. Folostina, (Eds), Interventions for Improving Adaptive Behaviors in Children With Autism Spectrum Disorders (pp.213-228). IGI Global. (2021).

40. K. Sarri, C. K. Syriopoulou-Delli, Robotics for enhancing independent living skills in adolescents and young adults with autism spectrum disorder: a systematic review. Research, Society and Development, **10**, 15 (2021).

41. P. T. Shattuck, S. C. Narendorf, B. Cooper, P. R. Sterzing, M. Wagner, J. L. Taylor, Postsecondary education and employment among youth with an autism spectrum disorder. Pediatrics, **129**, 1042-49 (2012).

42. C. K. Syriopoulou-Delli, K. Sarri, Video-based instruction in enhancing functional living skills of adolescents and young adults with autism spectrum disorder and their transition to independent living: a review. International Journal of Developmental Disabilities, (2021).

* 43. E. Walsh, H. Lydon, J. Holloway, An Evaluation of Assistive Technology in Determining Job-Specific Preference for Adults With Autism and Intellectual Disabilities. Behavior Analysis in Practice, **13**, 434–444. (2019).

* 44. D. M. Ward, M. C. K. Esposito, Virtual Reality in Transition Program for Adults with Autism: Self-Efficacy, Confidence, and Interview Skills. Contemporary School Psychology, **23**, 423-431 (2019)