Review Paper

Virtual reality and augmented reality as strategies for teaching social skills to individuals with intellectual disability: A systematic review

Journal of Intellectual Disabilities
2022, Vol. 0(0) 1–23

DOI: 10.1177/17446295221089147
journals.sagepub.com/home/jid
SAGE

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Abstract

Virtual reality (VR) and augmented reality (AR) programs have proliferated significantly in recent years and they are finding their way into different educational and therapeutic purposes. This systematic review aims at analyzing the virtual reality and augmented reality programs designed to promote the development of social skills in individuals with intellectual disability. Searches were carried out in the Scopus, Science Direct, Springer and Web of Science databases in the period from 2005 to 2020. A total of six articles met the inclusion criteria. A descriptive data analysis was performed. The results show that the clinical profile of the individuals who participated in the interventions is diverse. It can be concluded that there is some scientific evidence that points to the usefulness of VR and AR in the development of intervention programs to improve the social skills of individuals diagnosed with developmental deficits. However, it is necessary to acknowledge methodological limitations such as the lack of control groups, follow-up measures and of generalization of the results.

Keywords

virtual reality, augmented reality, intellectual disability, social skills

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According to the American Association on Intellectual and Developmental Disabilities (Asociación Americana de Discapacidad Intelectual, 2011), intellectual disability originates before the age of 18 and is characterized by significant limitations in both intellectual functioning and adaptive behavior. This conceptualization of intellectual disability, which is also adopted by the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders - DSM 5 (American Psychiatric Association, 2013), transcends the reduced explanation based on IQ. In fact, it is based on a model of disability that promotes offering sufficient support to improve the quality of life of these individuals in different dimensions.

As summarized in Figure 1, adaptive behavior is the collection of conceptual, social and practical skills that make it possible for individuals to function in their everyday lives (Asociación Americana de Discapacidad Intelectual, 2011). In this way, individuals with intellectual disability who have deficits in social skills may have difficulty in accurately perceiving social signals in a personal interaction, running the risk of being manipulated by others (Giménez-García et al., 2017; Horner-Johnson and Drum, 2006); they may have difficulties in regulating their emotions with respect to their age referent peers (Baurain and Nader-Grosbois, 2012; Baurain et al., 2013) or may not know how to adequately respond to the needs of another person (Smogorzewska et al., 2018). These skills are fundamental in the socialization process of individuals and have also been considered protective factors against possible dysfunctional behaviors or even psychopathological disorders (Betina Lacunza and Contini de González, 2011).

A review of scientific literature shows that there are numerous interventions aimed at promoting and improving the development of social skills in individuals with difficulties in this area. (see e.g. Hughes et al., 2012; (Merrells et al., 2018). Regarding the type of intervention traditionally used to teach social skills, cognitive-behavioral programs stand out with techniques such as modeling or video filming (Adeniyi and Omigbodun, 2016; Boluarte et al., 2006; Ratcliffe et al., 2019; Sequera et al., 2016).

Virtual reality and augmented reality in education and psychology

The emergence of information and communication technologies (hereinafter "ICT") has meant a revolution of an individual, educational and social nature that transcends the barriers of space and time, allowing access to information from different places and favoring new forms of socialization

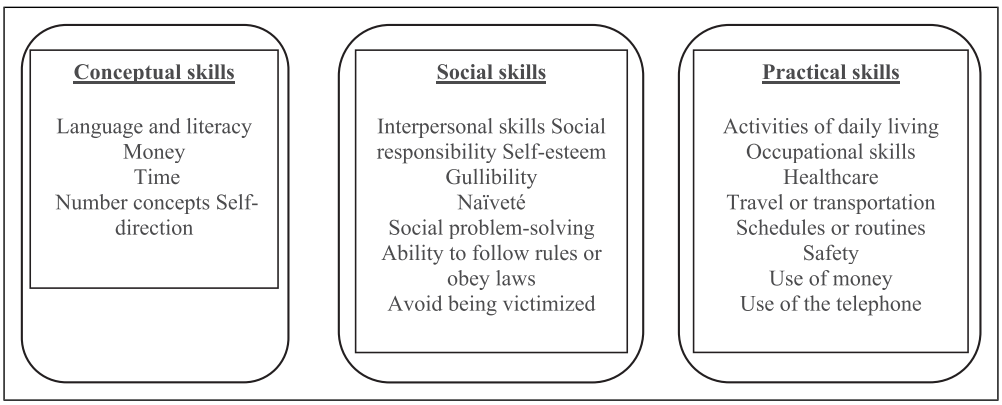

Figure 1. Adaptive behavior skill set according to AAIDD.

and communication (Espinoza and Rodríguez, 2017). Digital technologies offer possibilities beyond accessibility to information or new socialization and communication strategies, making it possible to promote, for example, the use of rehabilitation therapies (Arrastía-Lana, 2009) or to favor the development of complex skills, such as those of socio-affective nature, among others. This emergence of ICT has led to a specialization that resulted in the design, development and application of educational, professional or research resources. Likewise, the application of ICT was developed in different fields, including the area of special education (Castaño et al., 2019), which has meant great possibilities for the expansion and strengthening of deficient skills (Padilha, 2021).

Literature reveals that projects that use virtual reality (VR) and augmented reality (AR) have proliferated significantly in recent years (see for example Baragash et al., 2020; Valentine et al., 2020; Walker et al., 2019). The proposed definitions of both technologies are numerous and varied, as well as the scenarios in which these types of projects are developed. VR can be defined as an immersive technology, that is, it "tricks" the senses to transport a person to a different space than the one he or she is physically in (Aznar-Díaz et al., 2018; Vicent et al., 2015). Through digital devices integrated into a VR viewer, a virtual environment composed of images and sounds is presented. In such environment objects can be handled and freedom of movement can be provided through the use of haptic controllers (which can contribute to the improvement of sensations). In order to consider a VR design, the *simulation* conditions or the possibility of clearly replicating aspects of reality, *interaction* or control over objects and the simulated environment, and *perception* or suitability to stimulate the senses of users must be met (Pérez-Salas, 2008). The application of VR in educational settings is characterized by favoring constructivist learning, providing new learning alternatives and enabling collaboration among users beyond the physical space (Otero and Flores, 2011; Prefasi et al., 2010). In addition to this, authors such as Cuesta and Mañas (2016), Cózar et al. (2015) or Marín-Díaz et al. (2018) point out that its use increases motivation and digital competence.

AR is the technology that incorporates different virtual elements in the real environment (Basogain et al., 2007; Durlach and Mavor, 1995; Moreno and Leiva, 2017), thus contributing to the expansion of the perception of real physical information through classification systems based on the superposition of images (Cabero et al., 2017; Kato, 2011), complementing in this way the users´ context (Basogain et al., 2007; De Pedro, 2011). In addition to combining the real world with the virtual world, the AR is characterized by being registered in 3D and the interaction takes place in real time (Prendes, 2015), which implies that users must be able to trigger actions in the environment which is then modified by such actions. The application of AR in educational environments, despite its great potential (De Pedro and Martínez, 2012; Kato, 2011; Reinoso, 2012), has encountered difficulties especially due to its high cost (Gandolfi, 2018). However, it acquires an added value, as it happened with VR, due to the motivational factor (McEwen et al., 2014; Prendes, 2015) as it allows interactivity, play, experimentation and collaboration (González, 2013), in such a way that it reinforces learning and interest in learning (Reinoso, 2012; Terán, 2012). Terán (2012) further distinguishes between the advantages of using AR for the development of cognitive, spatial, perceptual-motor and temporal skills; the reinforcement of attention, concentration, memory and reasoning; or the activation of cognitive learning processes.

Application of VR and AR to individuals with developmental disorders

As stated above, the possibilities offered by VR and AR are finding their way into different educational and therapeutic purposes (Marín, 2018; McMahon et al., 2015; Ramírez et al., 2019). In relation to this, Lainez et al. (2018) point out that the resources created with AR contribute to the process of learning reinforcement for students with specific educational support needs, improving

the possibilities for establishing social ties. These authors carried out a study in which they used AR with a student with autism spectrum disorder (hereinafter "ASD") for the purpose of dealing with some of the communication and social interaction deficits he had and promoting abstract learning. The results revealed improvements in all treatment target areas. Several studies have taken advantage of the benefits of VR to stimulate different skills in children and adolescents diagnosed with ASD, in dimensions such as recognition of emotions and social skills (Serret et al., 2014; Wallace et al., 2017).

In the field of intellectual disability, Martín and Brossy (2017) designed and evaluated an AR experience with individuals with Down syndrome. The authors concluded that the participants of the study showed a higher degree of cognitive maturation, increased sustained attention and improved long-term memory. This progress has positive implications for learning and communication in individuals with Down syndrome. Ramírez (2016) carried out a study with students with moderate intellectual disability and concluded that the educational materials presented in RA contributed to the improvement of academic performance and of motivation towards learning. Other authors such as Arroyave and Freyle (2009) have analyzed the impact that a learning environment based on VR has on the self-determination of students with intellectual disability. The results revealed that after the intervention, their choice, decision-making and problem-solving skills improved by 30%. The most influential variables in these results were interest in activities, actions based on preferences, beliefs and personal expression, verbal and non-verbal expression of emotions and feelings, the use of suitable strategies to solve everyday problems and solving a problem individually.

Importance of this review

Given the contributions made by the different studies analyzed, it could be concluded that VR and AR can be used as simulation tools for therapeutic purposes, enabling guided learning of skills which can be transferred to everyday situations of real life. In relation to this and returning to the idea exposed at the beginning of this introduction about the importance of social skills to generate effective interactions, the procedures based on VR and AR for teaching these skills could be considered beneficial for those individuals diagnosed with intellectual disability and who present difficulties in their social skills.

However, and despite the multiple benefits of ICT in different disciplines, the provision of these supports to offer a response in teaching social skills to individuals with intellectual disability has not been generous. For example, the systematic review carried out by Grossard et al. (2017) analyzed 31 articles which showed that educational games using ICT can be employed to train specific skills such as recognition or production of directed facial emotions or other more general social skills such as interaction, collaboration and adaptation to specific social contexts. Although four of the articles presented in the review used VR-based procedures, the target sample in all of them was individuals with ASD. The results reported in the systematic review of Khowaja et al. (2020), who analyzed the use of AR for the improvement of skills in multiple dimensions of development of children and adolescents with ASD, goes along the same lines. These authors found that out of a total of 30 studies, only two referred to the training of social skills in a population with intellectual disability through VR or AR (Lorenzo et al., 2019; Takahashi et al., 2018). In the same vein, in the systematic review carried out by Bailey et al. (2021), who explore the research on VR/AR communication interventions for people with communication disability and neurodevelopmental disorders, only four of 69 studies referred to population with intellectual disability or "mental retardation". Considering these reported shortcomings in interventions specifically aimed at individuals with intellectual disability, it is essential to invest in the design of tools based on the latest technologies in order to meet the emerging needs of individuals with intellectual disability.

Based on the aforementioned arguments, the purpose of this systematic review was to analyze intervention programs with VR and AR support aimed at improving social skills of individuals with intellectual disability. To achieve this purpose, the following questions were raised:

- What are the characteristics of VR or AR-based interventions that aim at improving social skills of individuals with intellectual disability?
- How effective are these interventions?

Method

This review was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) criteria extracted from Page et al. (2021). Following the standard for systematic reviews, the different stages of the process followed are described below.

Information sources and search strategies. For this review, Scopus, Science Direct, Springer and Web of Science (WoS) databases were accessed. The keywords and boolean operators introduced were *virtual reality AND intellectual disability AND social skills*. Inter-judge agreement was reached between the first three authors to select these search words. The searches were carried out between July 7 and July 13, 2020.

Selection of studies. In a first phase (*identification*) we located the scientific articles published between the years 2005 to 2020. The records corresponding to lectures, other types of records that were not articles and duplicate records were removed, retaining the resulting subset. In the next phase (*screening*) the records that, according to their title, did not refer to the subject of interest were removed. The remaining articles were analyzed by three of the authors of this review independently. Each of them examined a group of papers by reading the abstracts and the full text in order to include those that met the following criteria: (a) Studies whose target population was individuals with intellectual disability (identified with intellectual disability diagnosis by the authors). Studies whose target population was individuals with ASD who presented comorbidity with intellectual disability were also included; (b) Studies describing interventions with virtual reality (VR) or augmented reality (AR) technology; (c) Studies in which the objective of the intervention was the training and stimulation of social skills of this population according to the definition of the AAIDD (see Figure 1) and (d) Empirical studies or study protocols. These criteria to filter the articles were applied sequentially and failure to comply with at least one of them was a reason for exclusion. If any of the articles raised doubts in relation to any of the inclusion criteria, they were reviewed by the other two authors. When it was necessary for the authors to clarify a technological issue, they asked one more of author who is an expert in digital technology. In the last phase (*included*) the final set of selected publications was compiled. The complete detail of the phases is provided in Figure 2.

Data analysis of the final selection. The three authors in charge of the final selection of records proceeded to extract and process data from the final set of articles included in the review. Each of them completed a matrix with *Microsoft Excel®* which included the following categories: objectives, characterization of the sample, research and intervention design, characteristics of the intervention tool and results. Finally, once the extraction of data of each article was concluded, a cross-checking was carried out by one of the other authors.

Results

Of the 761 records that the initial search yielded, six articles that met the requirements established a priori were finally selected. Table 1 summarizes the relevant information of the six articles included

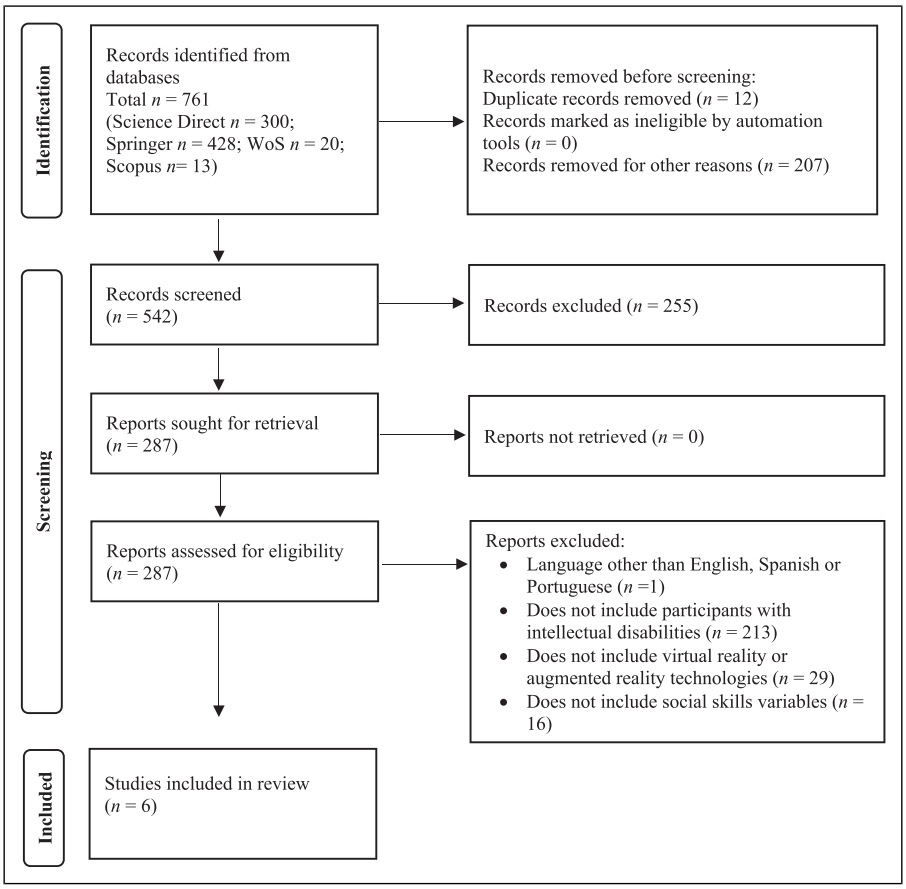

Figure 2. PRISMA flow diagram detailing identification, screening and inclusion of articles.

in this review, considering the characteristics of the samples, the objectives, the design, the variables, the instruments, and the main results. It should be noticed that all the selected papers have been published as of the year 2015 (Figure 3) and there has been a slight progressive increase thereafter.

Characteristics of the samples

The six empirical articles resulting from the review showed that the sample number of the studies ranged between 11 and 153 participants ($M = 51.90$; $SD = 54.096$). Regarding the age groups of the target population, two studies were exclusively carried out with the early childhood population (Byrne et al., 2015; Lorenzo et al., 2019), one study with adolescents (Takahashi et al., 2018), one with young adults (Burke et al., 2018) and two with mixed age groups: Butti et al. (2020), with participants from early childhood to early adulthood, and Burke et al. (2020), with participants from adolescence to early adulthood. In general, the ages of the participants ranged from 2 to 31 years ($M = 16.24$; $SD = 5.623$).

Table 1. Summary of the articles included in the review.

Study	Sample	Purpose	Design, variable(s) and instruments	Main results
Byrne et al. (2015)	72 severely intellectually disabled (SID) students, aged 6 – 20 (China)	To strengthen SID students' pre-learning abilities, self-awareness, decrease behavioral interferences with learning as well as social interaction, and enhance their communication.	Pre-test and post-test of a single group with SID	- Student participation (SFA): statistically significant increases after intervention, in four of seven school settings (special classroom, transportation, transitions, meal/ snack time) and in total score.
			Performance of active participation and functional task completions	- Adult assistance needs: statistically significant pre-post differences when performing general school functional tasks (less assistance required)
			- School Function Assessment (SFA); Inspal; Virtual Learning Platform.	- Adaptation needs subscale showed no significant increment - Self-initiated hand raising (basic communication skills): 50% increase during the intervention, compared to before and after the program.
Burke et al. (2018)	32 participants, aged 19-31, with autism and developmental disability (USA)	To examine whether ViTa system would improve job interviewing skills in individuals with autism and developmental disability.	Pre-test and post-test with single group design	- Interviewing skills (MIAS): total mean score increased by 0.58 units between the first ViTA session and the final face-to-face interview.
			Job interviewing skills and self-efficacy	- MIAS score for ASD participants specifically: increased by 0.49 units between the first ViTA session and the final face-to-face interview. Greatest increase between the third and fourth session.
			- MIAS; DMF; Self Efficacy scale; ViTA	- Results do not express programe alone effects, but in conjunction with explicit teaching.

(continued)

Table 1. (continued)

Study	Sample	Purpose	Design, variable(s) and instruments	Main results
Burke et al. (2020)	153 participants, average age: 21.71 years, with autism, Down syndrome, ADHD/ ADD, intellectual disability, cerebral palsy (USA) Prader-Willi syndrome, or other	To evaluate the measurable impact of ViTA on participants´ interviewing skills, perceived self-efficacy, and the relationship between program participation and participants´ MIAS score	Pre-test and post-test with repeated measures between subjects	- Interviewing skills (MIAS): total mean score increased by 1.09 units after the treatment.
			Job interviewing skills and self-efficacy	- Self-efficacy and sub-domains: adjusted increase was 0.27; 0.28 for strengths, 0.26 for career decisions and 0.25 general (after controlling for age, number of disabilities, sex and ethnicity).
			- MIAS;Self Efficacy scale; ViTA.	- Results replicate and extend Burke et al. (2018) positive findings
Butti et al. (2020)	42 children, adolescents and young adults, aged 7–25, with congenital cerebellar malformations and with an IQ greater than 45 (Italy)	To investigate the efficacy of a new, intensive, cognitive rehabilitation protocol in a sample of patients with congenital cerebellar diseases.	Pre-test and post-test with an active control group and an experimental group. Social Cognition - Theory of Mind Parts A and B; NEPSY-II; CBCL 6-18; TACQOL	No results (study protocol)

(continued)

Table 1. (continued)

Study	Sample	Purpose	Design, variable(s) and instruments	Main results
Lorenzo et al., 2019	11 participants aged 2 - 6, with ASD, intellectual disability, language disorder, development delay (Spain)	To explore whether the effect of AR intervention in children under 6 with ASD differs from a control group using traditional intervention (without AR).	Pre-test and post-test with repeated measures between subjects Social skills - IDEA (Inventario del Espectro Autista)	- Social skills-related dimensions (*Autism Spectrum Inventory)*: no pretest-posttest significant differences in overall score when comparing AR-based intervention and intervention without AR. Differences in some items in posttest (e. g. communicative functions and expressive language), though not statistically significant.

(continued)

Table 1. (continued)

Study	Sample	Purpose	Design, variable(s) and instruments	Main results
Takahashi et al. (2018)	20 students between 15–18 years of age with mild/moderate intellectual disability and/or ASD (for Circle Run activity)	To increase opportunities for interpersonal interactions among children with neurodevelopmental disorders by assisting their activities at school	Participatory design approach.	Circle-run: - The peacemaker stabilized the angle between runners, indicating that their position and running paces were adequately coordinated during trial (the visual aid had the capacity to modifystudents´running behavior: maintaining pace and position).
			Pre-test and post-test with an experimental group	- The running formation also showed enhancements during the post-trial, compared to pre-trial.
	23 students between 15–18 years of age, with mild/moderate intellectual disability and/or ASD (for Constellation game activity) (Japan)		Circle Run: students cooperative running behavior	Constellations Game:
			Constellation Game: Helping behaviors (HB) and positive behaviors (PB)	- The game facilitated students' PB and HB according to the increasing number of students who joined the game. - The game facilitated players to exhibit more HB when a positive mood developed among them (correlation coefficient: 0.83).

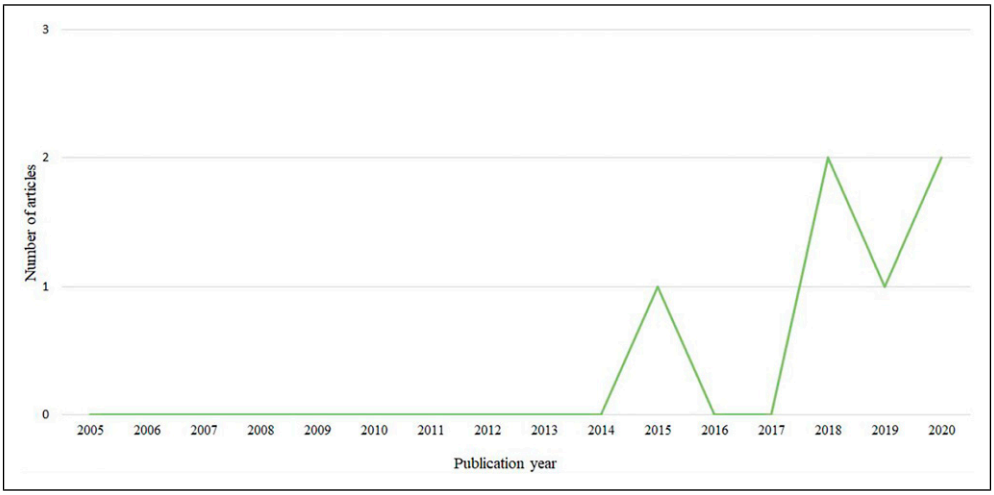

Figure 3. Distribution of articles within the search period (2005–2020).

A great disparity was found in the distribution by sex of the participants, with the percentage of male participants being the majority, although two studies did not report on this variable (Butti et al., 2020; Byrne et al., 2015).

In line with our inclusion criteria, all the samples reviewed presented participants with intellectual disability. Five studies worked with heterogeneous samples also composed by participants with other conditions or by cases of intellectual disability that presented comorbidity with other disorders. More specifically, four studies included participants with ASD (Burke et al., 2018, 2020; Lorenzo et al., 2019; Takahashi et al., 2018), some participants had been diagnosed with ADHD (Burke et al., 2018, 2020), a study included participants with SLI (Lorenzo et al., 2019) and, finally, in three of the studies the clinical profiles of some participants were associated with cerebral palsy, Down syndrome, Prader-Willi syndrome or unspecified developmental disorders, among others (Burke et al., 2018, 2020; Butti et al., 2020).

Research design

All the reviewed papers reported a pre-post design and the number of intervention groups as well as the inclusion of control groups was variable. Four of the studies worked without a control group (Burke et al., 2018, 2020; Byrne et al., 2015; Takahashi et al., 2018), while two included active control groups (Butti et al., 2020; Lorenzo et al., 2019). Another one of the studies used a participatory design that involved teachers and students both in the conceptualization of the intervention needs and in the design of the tool, and as observers in the feasibility tests (Takahashi et al., 2018). Regarding the analytical strategy used, it was generally descriptive and inferential. Finally, regarding the generalization of trained skills, Byrne et al. (2015) included the teacher report in the post-evaluations after observing the behavior in the educational context. No study had long-term follow-up measures.

Table 2. Characteristics of the intervention programs.

	Byrne et al. (2015)	Burke et al. (2018)	Burke et al. (2020)	Butti et al. (2020)	Lorenzo et al., 2019	Takahashi et al. (2018).
Program	Interactive Sensory Program for Affective learning (InSPAL)	Virtual interactive training agent (ViTA) system	Virtual interactive training agent (ViTA) system	VR-SPIRIT	Selection from Quiver Vision (application for Android)	FUTUREGYM
Developers	AIMtech Centre of City University of Hong Kong, China.	Dan Marino foundation-Florida department of Education´s Department of vocational rehabilitation - University of Southern California´s Institute for creative technologies (ICT), USA.	Idem Burke et al. (2018)	GRAIL VR laboratory (Italy), Motekforce Link (Netherlands)	Quiver Vision (geographical origin not reported)	Artificial Intelligence Laboratory and Center for Computational Sciences, University of Tsukuba, Japan.
Program background	Original, but built upon AIMtechCentre previous innovations in virtual environment for psychotherapy of abused children and smart classroom for affective learning.	Previously created	Previously created	Original	Adapting previously created Quiver Vision	Original

(continued)

Table 2. (continued)

	Byrne et al. (2015)	Burke et al. (2018)	Burke et al. (2020)	Butti et al. (2020)	Lorenzo et al., 2019	Takahashi et al. (2018).
Target population of the program *	Students with severe intellectual disability	Individuals with intellectual, developmental or autism spectrum disorders.	Idem Burke et al. (2018)	Patients with abnormalities in the cerebellum	ASD	Neurodevelopmental disorders
Type of technology	VR	VR	VR	VR	AR	SAR (Spatial Augmented Reality)
Type of administration	Individual	Individual	Individual	Individual	Individual	Group
Length and frequency	18 months, 32 sessions	4 sessions, the first taken as a baseline, the 2nd 61 days later, the 3rd 75 and the 4th 89 days later (on average)	4 sessions. 22 weeks between pre and post-test	8 sessions of 45 min	20 weeks, sessions of 15 min, twice a week	Not specified
Use of scenarios	8 scenarios	7 scenarios (eg. hotel lobby, office, warehouse breakroom)	7 scenarios (expanded to 144 possible situational contexts)	1 scenario (playground)	Yes. No explicit report on number (e. g. score a goal, interaction with a cow)	No scenarios
Use of avatars	Not reported	6 avatars (3 males y 3 females -virtual humans) of different ages and ethnical origins.	3 avatars of different ages and ethnical origins show a mild, neutral and hostile behavior.	4 avatars from which one is selected	Yes. No explicit report on the number	Not used

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Table 2. (continued)

	Byrne et al. (2015)	Burke et al. (2018)	Burke et al. (2020)	Butti et al. (2020)	Lorenzo et al., 2019	Takahashi et al. (2018).
Support of external agents	Yes	Not reported	Not reported	Not reported	Yes, therapist (demonstrations on interaction with AR, instructions, joint activities)	Yes, teachers
Description of the technology and environment	Virtual scenario combined with a motion and gesture recognition detector (Microsoft Kinect sensor)	3 cameras: HD camera for interview recording, backup webcam and XBOX GEN I KINECT system to track facial expressions. Samsung 60-70 inch HD screen to simulate the presence of avatars.	Requirements: computer, 24 '' minimum HD LCD, 3.5 mm speaker, 3.5 mm microphone, mouse and keyboard for remote operation.	VR environment projected onto a 180 ° cylindrical screen synchronized with a trademill	Application for Android telephone: Quiver Vision	Spatial augmented reality (SAR). Large-scale floor projection in a school gymnasium and screen.

(continued)

Table 2. (continued)

	Byrne et al. (2015)	Burke et al. (2018)	Burke et al. (2020)	Butti et al. (2020)	Lorenzo et al., 2019	Takahashi et al. (2018).
Description of the program	Psycho-educational intervention. Learning through trial and error based on action, repetition, accompanied by a facilitator, with the aim of acquiring greater body, mental and emotional control.	Virtual conversational platform in which avatars ask interview questions. Progression in difficulty. The intervention is also accompanied by ViTa curriculum, an explicit teaching interviewing skills curriculum.	Idem Burke et al. (2018)	Participants compete with one of four possible avatars, to reach one of three recreational objects. Elements of the environment induce participants to anticipate the movements of the avatar and his/her behavioral preferences.	Calibration phase. Activities: scoring a goal (feedback: cheering sound, response: shaking hands or "high five"); touching different AR objects following instructions from the therapist; imitating the therapist's behavior with an animal; asking the therapist for help to score a goal.	Circle-Run activity: it means running in groups and in circles (cooperative running following visual aids). Constellation Game: providing opportunities for helping behavior by defining a shared goal -forming a constellation by standing on certain floor spots, also following visual aids-.
Follow-up and/or generalization	No follow-up. Generalization: the results of the program are evaluated in the natural context of the classroom.	No	No	No	No	No

Note: * By target population of the program we mean the profiles for which the authors designed the intervention, not necessarily having to coincide with the samples that were finally used in the studies.

Characteristics of the interventions

As shown in Table 2, only two coincidences were found regarding the stimulation program used (ViTA; Burke et al., 2018, 2020). In addition to the specific VR and AR technology used to implement the intervention, three of the articles reported the additional use of cameras and/or motion detectors to capture specific aspects of the participants´ behavior and the environment during the intervention (Byrne et al., 2015; Burke et al., 2018; Takahashi et al., 2018). Additionally, with regard to the design of the interventions, five of the studies describe the use of scenarios, the number ranging from one to eight (the number was not reported in Lorenzo et al., 2019), and four programs used between one and six avatars (the number was not reported in Lorenzo et al., 2019). The interventions lasted between 20 weeks and 18 months (four studies did not provide this information) and completed between 1 and 40 sessions (the number of sessions was not reported in Takahashi et al., 2018). The study by Lorenzo et al., 2019 describes the use of preparatory actions for the intervention (calibration). Regarding the administration method, only one intervention was carried out in groups (Takahashi et al., 2018), while the others were administered individually. With regard to human agent guidance (therapist, facilitator, teacher, etc.), three studies considered it as a determining aspect of the intervention (Byrne et al., 2015; Lorenzo et al., 2019; Takahashi et al., 2018), while the remaining articles did not specify this aspect.

With reference to the target population for which the programs were designed - regardless of the sample that actually participated in the studies – in one of the cases the program was addressed to students with intellectual disability, while in the others the original recipients varied between different clinical profiles that mainly included high and low functioning ASD (see details in Table 1). The target constructs of the intervention in social skills were the following: performance in job interview and self-efficacy (Burke et al., 2018, 2020), prediction of the intentions of other agents in social settings (Butti et al., 2020), cooperative running, helping and positive behavior (Takahashi et al., 2018), participation, adaptation and communication skills in educational contexts (Byrne et al., 2015) and social skills (Lorenzo et al., 2019).

Effectiveness of interventions

Burke et al. (2020) regarded their intervention program -ViTA- as effective, indicating, through an analysis of repeated measures, increases in self-efficacy and job interview skills, even after controlling for age, number of conditions, sex and ethnicity. Burke et al. (2018), referring to the same program, had previously stated that it was promising, pointing out that the performance of the participants improved between the first and the last session, although they admitted that the true effect of the program could not be isolated because it was administered together with explicit traditional training.

Takahashi et al. (2018) reported that through their proposal, implemented during the performance of collective games in an educational context, it was possible to stimulate the manifestation of cooperative and positive behaviors.

Byrne et al. (2015) evaluated the effects of the intervention by observing behaviors in an educational center. This study reported the effectiveness of the InSPAL program and showed statistically significant increases in participation levels in four of the seven scenarios, as well as a decrease in the need for assistance by adults in an educational context. This was the only study that shows generalization of the intervention results. Through observations made by teachers and facilitators they found a 50% increase in basic communication skills (self-initiated hand raising) during the intervention.

Lorenzo et al., 2019 found no statistically significant differences between their social skills stimulation program administered through AR and a program with the same objectives without AR in the social area, communication and language, anticipation and flexibility, and symbolization. The authors argue that the sample size and the length of the intervention period could be possible explanatory factors.

In short, four of the reviewed studies reported results that support the effectiveness of the interventions in some of the proposed areas. On the other hand, one study (Burke et al., 2018) pointed out that it faced methodological limitations in attributing the effects to the program, while another study (Lorenzo et al., 2019) found no significant effects.

Limitations stated in the studies and considerations associated with the intervention

Some limitations highlighted by the authors refer to the size of the study samples. In particular, Lorenzo et al., 2019 mention this limitation, especially when the study is intended for a specific clinical population. Regarding the implementation, considerations related to good lighting of the evaluation environment were found when the technology involves the projection of images in space and motion of the participants (Takahashi et al., 2018). Other limitations identified by the authors refer to the metrics to evaluate the effects of the interventions, and the difficulty of distinguishing between task learning effects and intervention effects (Burke et al., 2018; Lorenzo et al., 2019). Also at the methodological level, the need for evaluators to be blind to certain aspects of training was reported (Burke et al., 2018; Lorenzo et al., 2019). The need to incorporate facial expression measures to evaluate behavior during the intervention was also highlighted, with the use of body-worn devices rather than overhead cameras being recommended for recording participant behavior (Takahashi et al., 2018). Regarding the evaluation of the impact of the interventions, Lorenzo et al., 2019 state the need to consider its length and frequency as well as the need to make sequential and successive evaluations.

Discussion

The objective of this systematic review was to identify learn about VR and AR programs aimed at developing social skills in individuals with intellectual disability and analyzing their effectiveness. Based on the results, it can be concluded, in general terms, that there is some scientific evidence that indicates that the use of VR and AR technology is useful in the development of intervention programs for the improvement of social skills of individuals diagnosed with certain types of deficits in their development.

Considering that this technology began to be used in the field of psychological treatments at the end of the last century, it was expected it would occupy an important place in the field of psychological intervention publications (Botella et al., 2006). Thus, the small number of empirical studies that finally met the inclusion criteria of this review is surprising. In fact, the small number of publications made since 2005 would allow us to conclude that this research field is far from consolidated. The notable differences found between the different studies point in the same direction. In this sense, the number of participants included ranges from 11 to 153, with generally small samples. In relation to the disparity seen in the distribution by sex, a possible explanation could be the gender bias in the diagnosis of some disorders reported in literature, such as ASD (Montagut et al., 2018). The fact that there is a much higher number of men who are diagnosed with ASD could explain this representative disparity in access to intervention programs. It is worth

mentioning that despite the fact that the keywords used in this search did not include any mention about autism or ASD, four of the six articles included participants with this disorder.

Regarding the ages of the participants, the samples show what has already been reported in literature as an intergenerational digital gap (González and Martínez, 2017) since no interventions are reported with elderly people. Furthermore, and in line with the opinion of Del Barrio et al. (2016), intellectual disability is usually associated with concepts such as prevention, early care, educational or labor inclusion. Concepts that evoke the idea of individuals who have special needs during childhood, youth or in adult life, but very rarely during eldery age.

Despite the fact that, as can be seen in Table 1, the samples that were finally used in the intervention are clinically heterogeneous -composed of patients with intellectual disability, ASD or language disorders, among others-, there is a higher presence of the ASD clinical profile in the original conception of the programs (see Table 2). That is, the conception of the programs is not specific for intellectual disability (except in the case of Byrne et al., 2015), nor is the study of the effects of the intervention. It is worth considering that the programs designed for ASD address certain needs that may not coincide with the population with intellectual disability and without ASD. This predominance of ASD clinical profiles in the design is consistent with previous reviews, such as those by Grossard et al. (2017) and Khowaja et al. (2020). Along these lines, Grossard et al. (2017) point out that there are few programs available for individuals with the most challenged intellectual capacity (e.g. low-functioning ASD). It is necessary to continue developing intervention proposals based on VR and AR in order to achieve improvements in social skills for individuals with intellectual disability; tools that allow the development of autonomy and independence from the social environment and, thus, the improvement of the quality of life of these individuals and their families.

Regarding the specificity of the effects of the interventions on individuals with intellectual disability, the results do not appear discriminated for this group in the studies that include participants with different clinical profiles. The intervention programs used vary in five out of six studies (two incorporate AR technology and the rest VR), as well as their length, the number of sessions carried out or the skills that are the object of training. Only two of the studies incorporate a control group and only one case study was found. This contrasts with reports of studies that use traditional cognitive-behavioral interventions which, possibly due to the solid background of this type of strategies, offer comparative data between experimental and control groups (Boluarte et al., 2006; Sequera et al., 2016). Most of the studies incorporated in this review coincide in the individual presentation format of the programs and only the study by Takahashi et al. (2018) used a group format.

Apart from these differences which may be typical of the characteristics of an emerging research topic, some limitations shared by the reviewed studies call our attention and should be taken into account in future research. For example, it would be a priority to establish systems for measuring the results of the programs as objective and functional as possible (none of the studies reviewed incorporated "blind" evaluators), in order to evaluate the real scope and effect of the programs used. Regarding the magnitude and stability of the effects, it should be noted as an important limitation that in no case are follow-up measures reported over time once the intervention has ended, and only one of the reviewed studies accounts for the generalization of the effects in natural contexts (Byrne et al., 2015). Despite the need to study the transfer of skills to the real-life context in populations with developmental disorders reported in literature (see Serret et al., 2014), the limitation of not including strategies to promote and evaluate generalization is an aspect already pointed out in other reviews that have analyzed both traditional interventions (Hughes et al., 2012) and those that use technology. In this regard, the systematic review carried out by Khowaja et al. (2020) reports that a

general limitation is the absence of generalization data, while recommending an increase in the sample number, the incorporation of long-term evaluations and a more equitable distribution by sex in the samples.

Due to its importance, we would expect further development of research in this field to overcome the aforementioned methodological constraints, and to continue formulating useful proposals. For this purpose, the accumulated knowledge from the research already carried out should be taken into account. It seems necessary to replicate the studies that have shown good results (see Burke et al., 2018, 2020), identifying in this way the elements that lead to successful outcomes of the interventions. The limitations found would be resolved with greater methodological rigor in the forthcoming proposals, mainly with regard to the use of control groups, follow-up measures and generalization of the results.

In short, the subject is of interest and the need for useful intervention proposals in the field of social competence of individuals with intellectual disability is clear. For the design of these proposals, no expense should be spared and we should always be willing to benefit from the possibilities offered by technological advances in other fields of science, such as AR and VR technology. It seems that the benefits can indeed be many, so quality research should be further developed in that direction.

Financing

This systematic review is part of the FSED_2_2019_1_156062 project funded by the National Agency for Research and Innovation (ANII) in Uruguay, through the "Digital Inclusion" Sectorial Fund: “Education with New Horizons". The digital resources of this project have been lent by the Foundation, Fundación Telefónica Movistar Uruguay.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Agencia Nacional de Investigación e Innovación grant number FSED_2_2019_1_156062. And the digital resources of this project have been lent by the Telefónica Movistar Uruguay Foundation.

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