Navigating Autism: The Role of Collaborative Virtual Reality in Social Skills Development

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Abstract: Autism Spectrum Disorders (ASD) require new interventions because social communication can be specially challenging. Such interventions could help social skills grow. Collaborative virtual reality (VR) technology enables having different interactive and engaging environments. It offers a promising ways for improving many skills since people can safely engage with others as well as learn with others. This paper reviews the application of collaborative VR in improving social skills among children with ASD. The reviews shows the potential of collaborative VR to simulate deeply dynamic social interactions in a carefully controlled setting as well. Different studies show that collaborative VR use can help children with ASD improve empathy, social understanding, and teamwork. However, there are still some difficulties including accessibility as well as the possible need for individualized interventions and potential sensory overload. This review points out the opportunities that collaborative VR provides for meaningful learning improvements and for the large practice of social interactions in an engaging way. It also discusses the actual obstacles,that need to be addressed, to completely maximize the advantages of VR technologies regarding social skills development in ASD. The provided analysis could help support innovation and research in the field.

1 INTRODUCTION

One important challenge for individuals with autism is that they often battle with communication and social skills. Autistic children often have major problems relating to others, and these problems can show up in many social situations. Frequently, these children battle with understanding facial expressions or with reacting suitably to other people's emotional suffering which are key parts of human interaction (Garfin and Lord, 1986). Difficulties also affect multiple nonverbal communication skills, such as gaze communication, which is important for performing all social interactions and developing all relationships (Weiss and Harris, 2001). Specific communication difficulties truly highlight how the social challenges encountered by people with autism are exceptionally complex and quite multidimensional, thus stressing the necessary need for carefully tailored interventions that directly address these particular areas of concern.

Autism Spectrum Disorder (ASD) has a wide-ranging array of conditions, stretching from low-functioning autism (LFASD) to high-functioning autism (HFASD) alike (Ahmad Basri et al., 2024). The spectrum thoroughly reflects the multiple abilities displayed by many people diagnosed with ASD emplasizing the challenges they face and the need for therapeutic approaches that address their specific needs.

In recent years, Virtual Reality (VR) has evolved as a tool with great potential for intervention in ASD. VR technology is engaging and highly enjoyable. It is thus recognized for its ability to substantially improve social skills among people with ASD. These particular VR aspects thoroughly catch the interest of ASD users, and motivate them to engage with therapeutic activities that are carefully designed to improve social interactions as well as communication skills (Ahmad Basri et al., 2024; Mosher and Carreon, 2021). This approach uses all of the engaging and interactive features of VR to make controlled environments where many people with ASD can safely practice and learn social skills.

Well-designed serious games are cost-effective and effective educational tools for all the different needs of autistic children. They could be tailored to meet their specific needs as well (Noor et al., 2012). Different plaforms have been intoridced for different purposes (Elshahawy et al., 2020a; Elshahawy et al., 2020b; Elshahawy et al., 2022). Since these games

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can be used across many homes, classrooms, or therapeutic settings, they offer a meaningful supplement to established educational approaches. Through the careful incorporation of elements that accommodate the special sensory and cognitive preferences of autistic learners, serious games are able to provide a more fitting learning experience. They help to maintain a certain level of focus and reduce anxiety through very structured and predictable interactions which autistic children often find reassuring (Ke and Moon, 2018). Serious games make learning more flexible and less overwhelming because the controlled environment allows adjustments to sensory inputs and interaction complexity. This tailored approach strengthens the development of many social skills and communication skills in a way that respects all of the special challenges autistic children face and thus improving every educational outcome.

Collaborative environments, since they are especially useful for teaching communication, could be outstanding training simulations for children with autism. These environments can be changed across many settings to improve a variety of skills. Collaborative virtual learning has an advantage over single-user 3D environments; it can meet all learning needs involving social interaction. This approach helps build important skills. Also, it uses the advantages of social learning to encourage and improve the learning experience (Wang et al., 2017). These environments can effectively tackle the special challenges and learning styles of autistic children by promoting highly interactive and exceptionally cooperative learning scenarios, which provides them with the tools needed to succeed socially.

There is no much of empirical evidence that currently supports the effectiveness of Virtual Environments (VEs) as a teaching tool for all individuals with autism (Mitchell et al., 2007). However, there are strong hints of potentially large benefits appear in some studies. As an instance, the study presented in (Strickland, 1996) carefully observed that two particularly low-functioning children with autism could appropriately track events in a thoroughly engaging VE by using orienting movements. Additionally, (Parsons et al., 2004) reported that all teenagers with Autism Spectrum Disorders (ASDs) could fully navigate and function in a virtual cafe environment presented on a desktop. Such findings support the fact that VEs may be a true potential to act as a therapeutic instrument for improving certain cognitive as well as social skills in individuals with autism.

CVEs allow users to communicate and engage within a shared virtual space. Within a typical virtual environment, users are presented a precisely computer-generated simulation of a particular scene or world. In addition, they can thoroughly explore it, and fully interact with it (Millen et al., 2011). This setup facilitates individual exploration. It also makes collaborative experiences better, allowing all participants to do activities together in a simulated setting.

This paper seeks to explore the teaching of social skills to autistic children by using Virtual Reality (VR) settings that have collaborative environments. These interactive VR platforms explore the ways in which they ease each learning type as well as improve each social competency through allowing all children to fully engage in every simulated social interaction. The paper gives perceptive recommendations for using VR in autism education. The recommendations are deeply informed by many studies and offer a more thorough look into effective practices and strategies.

2 INTERACTIONS IN CVEs

The study (Schroeder et al., 2006) thoroughly investigated each aspect of the design usability of 3D Collaborative Virtual Environments (CVEs). This included using analytical methods from different research efforts created to fully understand interaction dynamics within those digital settings. The initial study involved a strict quantitative analysis of action sequences. Every observable behavior was systematically categorized into eight fundamental categories: communicate (C), external (E; relating to events outside the virtual environment), gesture (G), manipulate (M), navigate (N), position (P), scan (S), along with verify (V). This approach, which was highly structured, not only cataloged behaviors but also clarified how participants either followed or strayed from social standards during interactions. Initially, most interactions appeared to focus on the looks and social customs of avatars. However, all interactions gradually shifted to more helpful communication about definite tasks, so many avatars were viewed as functional parts of the collaboration.

A qualitative approach was carefully used for the second analytical method. All transcripts of every verbal communication were examined throughout the CVE's different collaborative activities. This analysis carefully spotlighted the undeniably large roles that verbal and also non-verbal cues played within collaborative dynamics. It was thorough and detailed. It also gave plentiful understandings of the content as well as of the subtle details of social interactions. Positioning, navigation, gesturing, and object manipulation, each action in the virtual space, greatly eased communication and collaboration when executing the

task, having a large influence. These findings, with support from more research from (Steed et al., 2003), pointed out that social interactions in virtual places are not simple, in addition to giving detailed views of the participants interact with the virtual space as well as each other. (Tromp et al., 2003) employed statistical techniques. Such techniques analyze the frequency and sequence of the interactions noted, offering a more thorough overview of participant performance and collaborative behavior in CVEs. These studies offer a thorough and multi-dimensional view of all the ways that CVEs can support and also improve collaborative experiences, presenting large understandings for the effective design and implementation of virtual spaces for collaboration.

3 AUTISM AND SOCIAL TRAINING IN CVEs

Social skills are key focus areas for virtual reality training in autistic people (Ahmad Basri et al., 2024), especially assessing non-verbal responses, starting and keeping up conversations, and also managing emotional challenges with care. Within this framework, Collaborative Virtual Environments (CVEs) are exceptionally promising, particularly for greatly improving the social skills of autistic children through the utilization of absorbing virtual reality tools.

It was noted that interventions that promote role-play can offer large benefits to collaborative interactions inside CVEs (Parsons and Mitchell, 2002). Role-play encourages mental simulation, in addition to giving users chances to explore social standards in a secure setting. Because CVEs have the ability to mimic countless real-world interactions, users are able to experiment with and understand multiple social behaviors and cues without fearing any repercussions in the real world.

3D CVEs provide autistic youth with many benefits. Learners are able to take part in real social situations and realistic role-playing in a simulated space that is controlled with care in these environments. This learning method helps autistic children build social skills without frustrating peers or teachers and without risking negative consequences in the real world (Standen and Brown, 2006; Wang et al., 2017). These settings provide large advantages, particularly as they enable wide-ranging practice and steady learning of all specific social skills, which are commonly challenging for autistic learners.

The review provided in (Khatab et al., 2024) also stresses the important role that collaborative play has. Collaborative play improves communication skills for autistic children. Working towards shared goals in a CVE allows each autistic child to interact with each neurotypical peer under the total guidance and support of mediators, like parents or teachers, because it promotes multiple social skills and guarantees complete inclusivity. Integrating technology via an all-embracing environment effectively strengthens a number of social developments, as it gives each autistic child tools to navigate social interactions with added confidence as well as success.

There exists a lack of investigations exploring how evidence-based strategies, importantly cognitive as well as behavioral techniques, are integrated effectively into Virtual Reality (VR) environments for teaching social skills to each of the people with high-functioning autism spectrum disorder (HFASD) (Ahmad Basri et al., 2024). This gap strongly stresses the need for a more deep investigation into the methodologies used to change these therapeutic techniques for VR settings, also pointing out how this medium possesses important potential for both engaging and effective intervention.

The review provided (Thai and Nathan-Roberts, 2018) pointed out that VR interventions target social skills with large variability, stressing that there is no agreement on the most important skills to address in these settings. According to this finding, the field may still be exploring the best ways to use VR for social skills training. Mesa-Gresa et al. (Mesa-Gresa et al., 2018) encountered a wide range of social skills targets across the reviewed articles. This further indicates the diverse approaches and potential breadth of VR applications in social skills training.

Furthermore, as shown in (Millen et al., 2011; Cobb et al., 2002) Collaborative Virtual Environments (CVEs) and Shared Active Surfaces (SASs) are very effective when it comes to improving social skills and promoting collaborative interactions among children with HFASD. These findings suggest that CVEs can be used by autistic children as a dynamic platform that offers a supportive, highly engaging, and interactive place to learn and practice social skills. CVEs let these children safely explore and rehearse social interactions through peer interaction in a controlled setting, which is important for social development.

It is important to continue exploring and improving all CVEs as tools to help build social skills. To assist a number of HFASD people, investigation into how collaborative settings in CVEs can be greatly optimized to support exact educational and therapeutic outcomes is important. This exploration is quite important, for it has the potential to lead to fully tailored as well as highly impactful interventions deal-

ing with all the special needs of this population. Their ability to function socially along with emotionally in all wider community settings should greatly improve. This research importantly adds to both the academic and practical comprehension of VR and CVE applications, and it greatly affects the lives of people with HFASD by giving them important skills to better handle social challenges.

Virtual Reality (VR) content, according to (Parsons and Mitchell, 2002), could be carefully made to connect user-centered designs to proven strategies by including both cognitive and behavioral learning methods. Considering cognitive along with behavioral techniques have displayed effectiveness in many customary social skills training settings (Laugeson and Park, 2014), this integration is quite meaningful. These techniques have proven successful in physical environments. How they can be changed and used in virtual reality settings, however, is still not well-researched. This gap is evidenced by several reviews and research summaries (Mosher and Carreon, 2021; Mesa-Gresa et al., 2018; Thai and Nathan-Roberts, 2018; Glaser and Schmidt, 2022; Parsons and Mitchell, 2002), and it is pointed out by a lack of thorough studies exploring the instantiation of multiple cognitive and behavioral strategies in VR.

It is important to find out which thinking and behavior methods are most effective in VR and how to smoothly incorporate them into VR social skills training, as pointed out by the limited research. Effective strategies, identified and precisely implemented within VR, could importantly improve the engagement and effectiveness of the training while furnishing users with more specially personalized and flexible learning experiences. Therefore, some expansion of this research area is absolutely necessary to advance VR as a truly influential tool in educational and therapeutic contexts, particularly about the design of VR content that can affect the development of social competencies in multiple populations in an important manner.

4 EXPLORING STUDIES ON VIRTUAL ENVIRONMENTS FOR SOCIAL SKILLS TRAINING

Collaborative Virtual Educational settings (CVLEs) and Virtual Environments (VEs) have shown great potential for dealing with the social difficulties experienced by people with Autism Spectrum Disorders (ASD). This section looks at multiple studies that investigate multiple new methods for teaching social skills through technologies that allow people to collaborate and participate.

The iSocial program (Wang et al., 2017) is one example. It implemented the SCI-A curriculum into a 3D CVLE. This program helps all youth aged 11 to 14 practice social and behavioral skills within a safe, controlled virtual environment; it stresses many structured, engaging interactions.

Millen et al. (Millen et al., 2011) presented both Block Party and TalkAbout, a pair of CVE applications that are intended to encourage many social conversation skills and collaborative strategies. Many interactive tabletop experiences are also supported by Shared Active Surface (SAS) applications, showing a degree of adaptability and engagement of these tools in social skills training.

The work presented in (Mitchell et al., 2007) studied the use of a café VE by six adolescents with ASD, who were 11 to 16 years old. In an ordinary café setting, the study found truly important improvements in social reasoning and judgment, particularly about seating choices. The large potential of fully engaging VEs to effectively improve social decision-making in adolescents with ASD is truly pointed out here.

The work introduced in (Ke and Moon, 2018) developed one complete, 3D virtual playground by way of OpenSimulator specifically for all high-functioning autistic (HFA) children between the ages of 10 and 14. The study indicated that VR-based gameplay improved social interaction skills along with negotiation, initiation, as well as response behaviors. The results also pointed out the importance of changing gameplay. This is based on the specific requirements and also the skills of students.

I-interact (Elgarf et al., 2017) works on the eye contact of children who have trouble socializing to help them. The study used a VR serious game that had a three-level structure. Following several sessions, eye contact skills improved in participants aged 8 to 15, particularly when tasks were presented gradually as well as in an engaging way. The study also stressed that gamification and user-centered design can grow engagement.

As the studies introduced indicate, autistic children can collaborate in Collaborative Virtual Environments (CVEs). This provides an especially structured and completely supportive place for developing a wide range of important social skills, including communication, teamwork, and emotional regulation. Feeling safe as well as excited, children in CVEs watch then copy good social actions from others; this helps them learn from each other. This approach helps autistic children improve how they interact with oth-

Table 1: Comparison of some of the studies on Virtual Environments for Social Skills Training.

Study	Sample Size	Age Range	Focus	Key Findings
(Wang et al., 2017)	11	11-14	iSocial (3D CVLE)	Improved social and behavioral outcomes via structured, immersive practice.
(Millen et al., 2011)	Not specified	Not specified	Block Party, TalkAbout, SAS	Enhanced collaborative strategies and social conversation skills.
(Mitchell et al., 2007)	6	11-16	Café VE	Improved judgments and socially relevant reasoning in seating choices.
(Ke and Moon, 2018)	8	10-14	3D Virtual Playground	Enhanced negotiation, initiation, and response behaviors.
(Elgarf et al., 2017)	8	8-15	I-interact VR Game	Improved eye contact through gamified training of dyadic and triadic gaze.

ers. It gives them a safe space without pressure. This also helps lessen common problems, like social anxiety and sensory overload.

Studies show collaborative tasks in CVEs have a large effect. For example, Block Party and TalkAbout (Millen et al., 2011) encouraged communication skills and teamwork through multiple exercises that involved building rapport, taking turns, and communicating frequently. The iSocial program (Wang et al., 2017) also gave children goal-oriented assignments that improved decision-making and collaboration skills through social scenarios similar to those in the real world. According to Ke et al. (Ke and Moon, 2018), team-based gameplay in a 3D virtual playground improved multiple social interaction skills in addition to several negotiation, initiation, and response behaviors.

CVEs offer customization and adaptability. This makes sure that challenges and tasks match every participant's skill levels. This adaptability truly promotes meaningful engagement along with helping to completely avoid activities that are either excessively hard or excessively simple. The presence of neurotypical peers introduce many social models, and interactions are thoroughly promoted thus improving the collaborative environment. This dynamic encourages a certain degree of empathy along with a definite level of understanding among all neurotypical participants. CVEs are an effective collaboration tool for autistic people, since these people often face many social challenges because of certain attributes.

5 RECOMMENDATIONS FOR DESIGNING VR COLLABORATIVE ENVIRONMENTS

Based on the different case studieson collaborative virtual educational settings (CVLEs), the following recommendations are proposed to carefully guide the future design and implementation of VR collaborative environments. These recommendations stress the clear capabilities of CVEs as they address every specific need of autistic children. CVEs also teach multiple social skills.

1. Incorporate pedagogical design features: CVLEs should be designed with a goal-oriented approach embedding engaging stories and particular aspects of games or role-play. Goal-oriented activities provide important structure as well as purpose for autistic learners. In addition, these learners often excel in extremely predictable environments. Learners can build social skills and rehearse without fear of negative real-world results because role-play and narratives help simulate real-world situations in a safe, controlled, virtual area (Wang et al., 2017). Since CVEs feature collaboration, autistic children are always able to interact with peers in a manner similar to interactions in real life. They are always able to repeat scenarios as needed to fully master them. This iterative learning approach encourages communication and interaction skills more.
2. Adopt a user-centered design approach: A user-centered design guarantees CVEs completely fit

all needs of autistic children, their instructors, and also their parents, when appropriate. This indicates surroundings that are visually comfortable as well as minimal sensory overload, along with complete adaptability to each individual preference, for all children. This should also include interfaces that let instructors and parents easily keep track of multiple interactions. Learning objectives are thus met quite effectively. This approach holds large importance within CVEs. Virtual environments can be widely customized to more effectively address all specific challenges that autistic learners face, such as difficulty with eye contact or interpreting non-verbal cues.

3. Ensure environmental comfort and adaptability: CVEs settings should be intensely customized to comfortably fit personal preferences, like the lights as well as the precise arrangement, along with the exact height of objects. These changes are very important for the participation of autistic children and their well-being. Introducing challenges incrementally allows a gradual buildup of skills [(Wang et al., 2017). Learners do not thus experience overwhelming feelings. It is often much harder to make adjustments in physical settings and we should thus make use of this unique feature of virtual environments.
4. Make systems adaptive: Adaptive systems are necessary throughout CVEs to address the different needs autistic learners. Such systems could for example change how hard a task is, how quickly people interact, and what kind of feedback is given. The learning needs of all autistic children often appear highly individualized (Wang et al., 2017). This flexibility ensures that each child gets support made just for them. This is also very important for teaching social skills. Adaptive systems in CVEs permit modifications at all times, thus supplying prompt responses to all user behaviors along with greater participation and many educational outcomes. Adaptability within virtual environments is important, according to (Ke and Moon, 2018), since gameplay made for each High-Functioning Autistic (HFA) child raised overall engagement and also some social skills such as negotiation and initiation. To be more effective, this finding supports the recommendation that teachers customize learning scenarios in CVEs, allowing adjustments to tasks and settings that accommodate each child's skills and preferences.
5. Include Neurotypical Peers: As discussed earlier, integrating neurotypical children within CVEs encourages inclusive learning and provides autistic children important opportunities to carefully observe typical soicial behaviors. Collaborative tasks with neurotypical peers can build multiple teamwork skills, diverse communication styles, and empathy (Khatab et al., 2024). The collaborative settings of CVEs helps with positive social interactions and decreases anxiety in autistic children by giving them a safe space for interactions with neurotypical peers, when compared to actual settings. In collaborative places, autistic children can watch and copy social actions. This helps them learn from others, which is very useful for those who battle with unplanned situations. Joint activities in virtual environments, as demonstrated by (Millen et al., 2011) with Block Party and TalkAbout, improved conversational skills by encouraging rapport and allowing all participants to practice initiating and sustaining dialogue.
6. Customize learning scenarios: Customizable scenarios in CVEs allow educators to considerately tailor activities to the specific needs and also the individual goals of each learner. For instance, scenarios can be designed to focus on initiating conversations, practicing turn-taking, or responding to non-verbal cues (Khatab et al., 2024). This special flexibility of virtual environments allows for the creation of many diverse social skill-building activities. A collection of such activities are needed but hard to in every customary classroom setting.
7. Standardize evaluation methodologies: To check and evaluate the effectiveness of CVEs interventions based, stable and standard evaluation methodologies are cruical. Standardization guarantees a dependable comparison of outcomes across many studies and settings.
8. Conduct extended follow-up sessions: Extended follow-up sessions over extended periods are always important to make sure all the long-lasting effects are captured. This is particularly important for children with Autism since sometimes the sample of children is not big. Thus, we need a more thorough in-depth analysis of the effects. These sessions can help determine if skills from the virtual setting transfer to real interactions to recognize areas that need more support. CVEs can replicate actual situations many times, which makes follow-up sessions very helpful. Learners can review and also strengthen skills previously learned over a period of time as well.

By integrating the proposed recommendations, we hope that every future CVE system would precisely fit all special needs of children with autism. This would

definitely yield social skills training that is effective and highly engaging. It would also be thoroughly personalized. The collaborative and flexible nature of CVEs provide a platform to help strengthen the social competence of users. This would help learners achieve good milestones.

6 CONCLUSIONS AND FUTURE WORK

This paper looked into how Collaborative Virtual Environments (CVEs) could change how autistic children are taught social skills. CVEs offer remarkably collaborative, exceptionally customizable, along with specially engaging platforms as they handle important challenges present in common social skills training. The reviewed studies show that they work well to help negotiation skills, initiation skills, and also conversational abilities. User-centered customization and goal-oriented tasks became a few design principles to improve engagement and learning outcomes. Peer collaboration also became a design principle to improve engagement and learning outcomes. Even with these genuinely encouraging discoveries, much more thorough research is required to fully comprehend the full potential of CVEs.

Future work should focus on several key directions.Longitudinal studies must explore how CVEs change people over time and how well social skills are kept and used in the real world. Gaining a comprehension of the degree to which CVE-taught skills are durable across time and varied situations will offer helpful understandings regarding their overall sustainability. AI integration into CVEs could also result in adaptive learning systems that change in response to user behavior. AI-driven environments offer custom feedback, immediately change task difficulty, along with delivering support that fits quite a few individual needs, to gain optimal engagement as well as wide-ranging learning. Third, research should explore how CVEs can supplement every customary therapy, developing many hybrid models combining virtual tools with every established intervention, for example, behavioral therapy or speech therapy. This integration could truly lead to therapeutic programs that are exceptionally all-including and undeniably impactful. Finally, more study about the role of neurotypical peers in CVEs is needed. Further research should be done. Understanding how inclusion really affects the social development of autistic children might help guide ways to promote inclusivity and build varied educational environments. It's also important to study less engaging tools that could use hololens. This is to check if it gives people with Autism a better learning experience. In many situations, Mixed Reality has proven to be generally effective (Farouk et al., 2022).

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