VIRTUAL REALITY AS AN INTERVENTION FOR INDIVIDUALS DIAGNOSED WITH AUTISM SPECTRUM DISORDER

by

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Abstract

The prevalence of autism spectrum disorder (ASD) is now 1 in 36 children (Centers for Disease Control and Prevention, 2023). People with autism may exhibit differences in social skills, so researchers are analyzing a variety of interventions to understand which yield the best results to support evidence-based practice. Therapy often addresses social skills, including conversation, and research is needed to explore which interventions are most effective. Virtual reality (VR) has recently been studied as an intervention in allied health fields such as physical therapy, occupational therapy, nursing, and psychology, but few studies exist in the field of speech-language pathology. A VR intervention program was created to teach conversational skills to adolescents diagnosed with ASD. In this first study, the perceived applicability and usability of the program was described from the perspective of speech-language pathology graduate students, licensed speech-language pathologists, and other individuals who have experience communicating with people diagnosed with ASD.

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Chapter 1: Literature Review

Autism Spectrum Disorder

In accordance with the American Psychological Association (APA) and the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5; American Psychiatric Association, 2013), autism spectrum disorder (ASD) is defined as a developmental and neurological condition characterized by differences in social communication, restricted interests, and repetitive behaviors. Social communication differences may affect social-emotional reciprocity, use of nonverbal communication, and developing relationships (American Psychiatric Association, 2013; Centers for Disease Control and Prevention, 2023). Restricted interests encompass hyper-fixation and the desire for situations to be predictable (American Psychiatric Association, 2013; Centers for Disease Control and Prevention, 2023). Lastly, repetitive behaviors may involve motor movements, echolalia, and hyper- or hyposensitivity to sensory input (American Psychiatric Association, 2013; Centers for Disease Control and Prevention, 2023). Severity may vary among individuals, but hallmark behaviors of ASD are present in early stages of development and may lead to differences in social participation, maintaining occupational responsibilities, and/or completing daily functions (American Psychiatric Association, 2013; Centers for Disease Control and Prevention, 2023). Approximately 1 in 36 children are diagnosed with autism spectrum disorder in the United States with a higher prevalence in males than females (Centers for Disease Control and Prevention, 2023).

Social Skills

Social skills can be defined as an umbrella term for those skills necessary for achieving communicative competence (Beukelman & Light, 2020). Social skills may be divided into two types: sociolinguistic and sociorelational skills. Sociolinguistic skills, also referred to as

('pragmatics'), include the following: greeting others, initiating small talk, topic organization and maintenance, turn-taking, wrapping up a conversation, and effectively ending a conversation with a farewell (Beukelman & Light, 2020; Zhang et al., 2022). In contrast, sociorelational skills contribute an interpersonal component to a conversation. Examples of sociorelational skills include orientation to the communication partner (i.e., facing the partner), looking toward the partner (i.e., eye gaze), active listening using nonverbal acknowledgers, and recognizing nonverbal cues from body language that signal the end of a conversation (Beukelman & Light, 2020). Social skills are important for developing relationships, academic and professional success, and completing activities of daily living (Moody & Laugeson, 2020). Further, social skills may improve quality of life, self-esteem, and contribute to an individual's happiness (Moody & Laugeson, 2020).

Children with ASD may exhibit differences in social communication such as variability in expressing thoughts, ideas, and feelings with others, understanding emotions, reduced eye contact, decreased use of nonverbal cues, difficulty interpreting nonliteral language, and challenges in forming relationships with peers (American Psychiatric Association, 2013). Lorenzo et al. (2016) described the emotional development of children diagnosed with ASD as "diverg[ent]" from other children, which could lead to misinterpretations of communicative intent (p. 193). Interventions for improving these communication differences include social skills training completed individually or in group settings, or speech and language therapy to improve the child's understanding of pragmatic language in social constructs (American Psychiatric Association, 2013). Social skills interventions are often used to instruct and enhance conversational abilities. Beukelman & Light (2020) define the five components of conversation as: greeting, small talk, information transfer, 'wrap up,' and farewell. These skills are often

taught through video modeling, priming, self-management, social stories, script training, and pivotal response training (Scattone, 2007). Recently, virtual reality has become the subject of an emerging body of research for its potential application as a therapeutic intervention used in clinical practice (Zhang et al., 2022).

Virtual Reality

Virtual reality (VR) can be defined as a simulation of real-world elements depicted through the use of computer graphics (Bellani et al., 2011). Further, it has been reported that this emerging technology could potentially be used as a therapeutic tool to promote learning and development while conducting intervention in a safe and controlled environment (Bellani et al., 2011). Types of VR include desktop simulations, cave automatic virtual environments (CAVEs), and head mounted displays (HMDs). Desktop virtual environment graphics are retrieved via a computer and are arguably more cost effective than other forms of VR that require additional equipment (Furht, 2008). Desktop VR is considered 'non-immersive.' Both CAVE environments and HMDs can be considered true 'immersive' virtual reality in which an individual is fully present in the virtual environment, with little or no interaction with their real-world surroundings. CAVEs were developed in 1992 and are comprised of a cube-like room in which projections are displayed on all four walls in addition to the floor and ceiling, fully immersing the user in the environment (Alqahtani et al., 2017). Lastly, and recently the most popular, head mounted displays (HMDs) require a user to wear a headset to experience a three-dimensional, virtual environment. HMDs allow the user to interact with the environment while utilizing natural movements, simulating an almost identical experience to real-world environments (Mehrfard et al., 2019).

VR is currently serving many purposes including recreational gaming (Pallavicini, 2019), collaboration (Drey et al., 2022), education (Izard et al., 2017), training resources (Xie et al., 2021), and recently, intervention services (Adabla et al., 2021; Campo-Prieto et al., 2021; Chen et al., 2022, Cote et al., 2023; Plotzky et al., 2021). In the field of speech-language pathology, interventions utilizing VR have been conducted for individuals who stutter (Chard et al., 2023; deLeyer-Tiarks et al., 2021), as well as those affected by brain injuries (Chiu et al., 2023; Oliveira et al., 2020; Zhu et al., 2021). Researchers are exploring VR interventions within the ASD population to teach daily living skills such as grocery shopping and job interviewing (e.g., Adjorlu et al., 2017; Moon & Ke, 2019; Parsons et al., 2006; Smith et al., 2014).

Additionally, virtual reality interventions have been used with people diagnosed with ASD to improve conversational skills (e.g., Ip et al., 2022; Ke & Moon, 2018) due to the potential advantages VR has to offer for this population that are described next. One advantage is that boys with ASD were found to have a high rate of video game usage (Coutelle et al., 2022). In fact, Zhang et al. (2022) reported VR environments can integrate gamification approaches, consequently enhancing motivation, attention, and focus. A second advantage for using VR is that children and adolescents with autism tend to have strengths in visual processing (Ip et al., 2018). A third advantage to using VR interventions with the ASD population is the ability to create a safe environment, that is repeatable and offers the potential for generalization (Glaser & Schmidt, 2018; Ip et al., 2018; Parsons, 2016; Zhang et al., 2022). Through the use of VR, interactions can be recorded and provide therapists the opportunity to discuss and provide relevant feedback (Moore et al., 2005). Lastly, virtual environments may foster feelings of security for the user (Glaser & Schmidt, 2018). The simulated environment allows individuals

diagnosed with ASD to experiment and learn from their mistakes with fewer adverse, real-world consequences (Moore et al., 2005; Parsons & Mitchell, 2002; Zhang et al., 2022).

VR and Conversational Skills

A plethora of studies have been conducted that implement intervention techniques that teach conversational skills, a primary difference of many individuals with autism. The training has allowed users to engage in repeated practice of skills in a natural environment, also referred to as collaborative virtual learning environments, or CVLEs (Glaser & Schmidt, 2018). In a study by Beach & Wendt (2016), participants with ASD stated they felt less stressed after practicing conversational skills in a virtual environment. Studies have analyzed specific components of conversation including greetings, topic maintenance, eye gaze, recognizing cues, and farewells. Relevant literature will be reviewed below.

Greetings

Adolescents with autism increased the number of greetings that they used following an intervention using a head mounted display (Cheng et al., 2015). This is the only intervention study to date that used HMD for this target. There are additional studies that utilized non-immersive environments to teach greeting including Crowell et al. (2019) who observed an increase of social initiations when adolescents played a video game based non-immersive simulation. Additionally, Wang et al. (2017) found the children had a decrease of inappropriate interactions, but they also noted that the participants still demonstrated fewer initiations than responses. Furthermore, Ke and Im (2013) observed 75% of participants had more conversational initiations following intervention. In a later study by Ke and Moon (2018), overall improvements for use of greetings were noted, however, individual gains were minimal. Lastly,

Ke, Moon, and Sokolikj (2020) conducted another study in which the majority of participants increased the total greetings they used.

Topic Maintenance

Topic maintenance is an essential skill for having an effective conversation and encompasses what many know as 'turn-taking.' Turn-taking includes asking questions, making comments, and responding to the communication partner. Çimenli et al. (2022) further define topic maintenance as a "collaborative process of managing the substance of a conversation" (p. 2). Three studies have investigated this skill using non-immersive virtual environments. Results from Ke and Im (2013) demonstrated variable results across all four participants, but in another study by Ke and Moon (2018), the results were positive and showed improvement of turn-taking skills. Crowell et al. (2019) also found that adolescents with autism displayed a positive increase in the number of responses they made in a social interaction following intervention.

Eye Gaze

Because many individuals diagnosed with ASD have an aversion to making eye contact with others (American Psychiatric Association, 2013), some studies have implemented training to teach eye gaze skills, or the ability to orient to others during a conversation to display active listening skills (Bekele et al., 2016; Cheng & Ye, 2010). Bekele et al. (2016) tracked eye gaze data during a feasibility study using a non-immersive simulation in which the 'gaze group' was provided with feedback during intervention about specific gaze patterns, and the control group was not provided with any feedback. The group that received feedback moved their gaze toward the conversation partner's eyes/forehead, rather than the partner's mouth, when given feedback about their behavior (Bekele et al., 2016). Additionally, Cheng & Ye (2010) tracked eye gaze patterns using a non-immersive virtual environment in which all three participants improved eye

contact across baseline, intervention, and maintenance periods. It is important to note that some professionals argue the importance of teaching eye gaze, rather than direct eye contact, because it may seem unnatural or make those with ASD feel uncomfortable (Hadjikhani et al., 2017). Eye gaze is simply looking toward the communication partner's face instead of staring directly into their eyes, ultimately making communication more natural. (Cañigueral & Hamilton, 2019).

Recognizing Cues

Emotion recognition has gained popularity as an intervention target for individuals diagnosed with ASD due to the close alignment with social competence and the ability to understand the perspective of others, also known as 'Theory of Mind' (Kouo & Egel, 2016). Emotion recognition is particularly relevant for understanding body language that could signal the end of the conversation and the need for 'wrap up.' The following studies have utilized VR to teach emotion recognition, with the majority utilizing non-immersive desktop simulations. Research by Cheng and Ye (2010) found that children improved emotion recognition abilities, with one of three participants displaying continued improvement during the maintenance period when data were collected randomly for three days following intervention. Cheng et al (2015) reported that children who underwent the VR intervention demonstrated a better understanding of non-verbal communication (i.e. recognizing emotions). Notably, 100% of the data from the single-subject design was non-overlapping, meaning that all data points in the intervention phase were above the data points in the baseline phase, indicating a high efficacy of the VR intervention (Cheng et al., 2015). Similar outcomes were observed in studies by Didehbani et al. (2016), Kandalaft et al. (2013), and Stichter et al. (2010) where participants also showed significant improvement in emotion recognition.

In a later study by Stichter et al. (2013), social skill training was conducted with adolescents using a head-mounted display. The authors reported improvement in emotion recognition, highlighting the potential of immersive VR technologies for enhancing social skill interventions (Stichter et al., 2013). Similarly, Ip et al. (2018) used a half-CAVE VR environment in which participants improved emotion recognition, emotion expression, and emotion regulation. Further, Lorenzo et al. (2016) compared performance on an emotion recognition task between a half-CAVE environment and traditional desktop-based virtual environments. The results demonstrated participants had more improvement when using the immersive half-CAVE environment when compared to the non-immersive desktop VR (Lorenzo et al., 2016).

Farewells

Lastly, two studies measured the independent use of appropriate farewells to end a conversation by utilizing non-immersive virtual simulations. Results from Ke and Im (2013) indicated all participants improved their performance when ending a conversation by using farewells such as ‘goodbye’ or ‘see you later.’ Trepagnier et al. (2011) primarily focused on the usability of a virtual conversation partner; however, the results showed that the participants chose an appropriate farewell response, but their improvement was not statistically significant. While both studies included ending a conversation as an intervention target, neither explicitly taught the participants how to ‘wrap up’ the conversation before parting and verbalizing a farewell. A ‘wrap up’ consists of remarks that signal a person’s intent to end a conversation (Beukelman & Light, 2020).

Research Objectives

There have been recent developments in virtual reality and its application within social skills training for individuals with autism that has sparked the interest of many researchers. However, few studies exist which explore the therapeutic use of VR in developing communication skills such as analyzing topic maintenance, eye gaze (specifically looking in the general direction of the conversation partner, not necessarily eye contact), small talk, understanding nonverbal cues (reading nonverbal cues, using nonverbal acknowledgers, and recognizing cues that may suggest the end of a conversation), and wrapping up a conversation. As for the studies that do exist, many are case studies or have small sample sizes. Also, most of the studies discussed above focus on virtual reality simulations utilizing programs that can be run on a desktop monitor rather than a head-mounted display using immersive VR. Furthermore, only a handful of these studies have been conducted in the United States. This is relevant to discuss because social norms, including attitudes and behaviors, may vary across cultures. While social skills training falls under the scope of practice for speech-language pathologists (SLPs), few studies have been conducted by these professionals looking at the efficacy of VR interventions for people with ASD. Existing studies have acknowledged limitations including how individuals with physical and/or learning disabilities may be affected when wearing a VR headset, if cybersickness will affect users, the unrealistic nonverbal behaviors of avatars, and lack of gamification (Parsons & Mitchell, 2002; Zhang et al., 2022). Future research is particularly relevant with Apple's release of the Vision Pro headset in February 2024 (Gerken & Kleinman, 2024). The literature has shown promising results for VR as an intervention with allied health professions; but few studies have analyzed the effectiveness of VR as a speech-language pathology intervention which may be used to enhance the development of

communication skills among clients with ASD. Additionally, many of the studies mentioned above targeted intervention toward adults with ASD rather than adolescents. Therefore, this study had the following research objectives: (1) To investigate the perceived applicability of virtual reality as a speech-language therapy tool and (2) To evaluate the perceived usability of a virtual reality simulation to teach conversational skills to adolescents with ASD. This study was designed as a pilot study to gather initial data on the usability and applicability of virtual reality. These objectives were met using the perspectives of speech-language pathology graduate students, licensed speech-language pathologists, and professionals who have experience interacting with people who have ASD. Participant demographics will be discussed in detail in the results section.

Chapter 2: Method

Design

The study analyzed the usability of a VR intervention designed for adolescents (ages 10-18 years). Using a mixed-methods design, speech-language pathology clinicians and other adults who have experience communicating with individuals who have ASD evaluated the program from the perspective of the adolescent user by completing the intervention and a survey describing their experiences. Quantitative data from the survey was analyzed by using measures of central tendency including averages and ranges. Qualitative data was coded for common themes and followed methodology of Creswell and Poth (2016). All responses remained completely anonymous to maintain confidentiality.

Participants

Upon approval from the Radford University Institutional Review Board, 20 participants were recruited from Radford University and the surrounding New River Valley utilizing

purposive sampling. Purposive sampling is when participants are purposefully chosen based on characteristics or criteria they possesses. Participants were recruited with purposive sampling out of convenience for the researchers. The participants trialed the VR simulation and conversational skills intervention. Participants consisted of 10 graduate students in speech-language pathology, five licensed speech-language pathologists, and five people who have experience communicating with individuals who have ASD (e.g., family members, occupational therapists, applied behavior analysis therapists, special education teachers). Inclusion criteria for graduate students in speech-language pathology and licensed speech-language pathologists were the following: (a) have experience providing intervention to at least one individual with ASD; (b) have hearing and vision within normal limits with or without correction; and (c) be at least 18 years of age. Inclusion criteria for adults who have experience communicating with individuals diagnosed with ASD were the following: (a) have communicated with an individual who has ASD on a weekly basis over a period of at least six months; (b) have hearing and vision within normal limits with or without correction; and (c) be at least 18 years of age.

Materials

A researcher with expertise in VR development created virtual environments and programmed avatar interactions for the experience. Equipment consisted of two Meta Quest Pro VR HMDs capable of eye and facial tracking and two Windows-based PCs. Each laptop was equipped with an Intel i9 processor along with a Nvidia RTX A4500 graphics card and 32GB of RAM. The VR experience was developed using the Unity game engine. Photon Fusion 2 was used to network the two HMDs so that the participant and clinician could interact with one another.

Procedures

Each participant was provided with informed consent prior to the beginning the study. Trialing the intervention and providing feedback via a survey with closed and open-ended questions took approximately 90 minutes. At the beginning of the study, participants received instruction on how to use the equipment (see Appendix A).

The intervention program consisted of 5 virtual environments (see Appendix B) in which participants completed a gamified approach to intervention by earning coins. Each environment included a game for participants to play as a reward for practicing conversational skills. Due to programming issues, these functions were not active during testing; however, participants were provided with descriptions of how the game would be implemented as a reinforcer. The first and last environments (a lake) were used for pre- and post-measures of target behaviors, and no cueing or direction was given to participants. Pre- and post-measures occurred in the same virtual environment to ensure that progress could be strictly attributed to the intervention received, rather than components of another virtual environment. The second, third, and fourth environments were a bowling alley, classroom, and carnival used for teaching conversational skills, and cueing was provided by the researcher as necessary to ensure learning and sufficient mastery of target skills (see Appendices C-G for the scripts and data sheets). The researcher provided detailed instruction of each target behavior in the first treatment environment (i.e., the bowling alley), and the participant had an opportunity to practice each conversational skill. Reminders of previous instruction were provided in the second and third treatment environments (i.e., the classroom and carnival), and the participant completed 10 trials of practice for each target behavior (five trials per environment).

In the final virtual environment, participants interacted with an avatar that utilized the GPT API provided by OpenAI. Incorporation of Artificial Intelligence (AI) was used as a

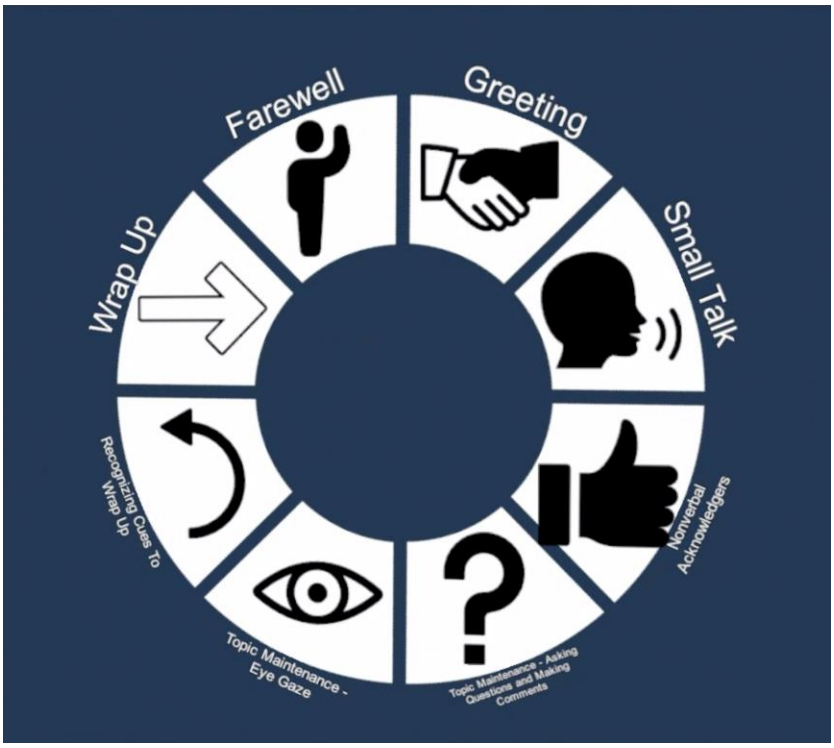
generalization measure to understand participant interactions with novel, neurotypical individuals during conversation in order to analyze overall progress after completing the VR intervention. The following system prompt was provided to the AI: “Generate a conversational response for an AI avatar interacting with a young individual with autism in a VR environment. The user has initiated the conversation with a general greeting or a question about the avatar's day. Respond in a friendly, engaging manner, appropriate for an adolescent. The conversation should be positive, straightforward, and comforting, avoiding sarcasm, complex idioms, or potentially triggering content. If the user seems confused or asks for clarification, the avatar should patiently rephrase in simpler terms. You should not mention that you are an AI. Be as close to human as possible." Providing the system prompt to the AI controlled the types of responses given by the AI.

As participants completed the intervention, they had the opportunity to earn points and play games by demonstrating target behaviors, similar to drill play that most children participate in during traditional speech therapy sessions. Target behaviors included: (a) greetings; (b) small talk; (c) nonverbal acknowledgers when listening to a nonpreferred story; (d) topic maintenance about a nonpreferred topic (i.e., asking questions, making comments, and eye gaze); (e) recognizing cues to ‘wrap up;’ (f) ‘wrap ups;’ and (g) farewells. To track progress, each participant was awarded one point if the desired behavior was demonstrated, and points could be recorded using a radial menu (See Figure 1). The radial menu was accessible via a button press on the controller. Target behaviors were highlighted on the menu and selected by pulling the trigger on the controller. The selected icon turned blue, indicating a point was awarded to the participant. Upon completion of the intervention, a file report may be generated with the

participant's performance. The researcher provided pre-determined cues as necessary, but no points were awarded if the desired behavior was not demonstrated independently.

Figure 1

Radial Menu Used for Data Tracking



Participant experiences were evaluated using a survey. The participants were asked a series of fixed responses (i.e., 5-point Likert scale) and open-ended questions to provide information about their overall experience, comfort and ease of learning with the headset and program, as well as ease of interactions during the intervention (see Appendix H). Results are presented below.

Chapter 3: Results

Table 1 provides demographic information of the participants who completed the study. Participants consisted of 10 graduate students in speech-language pathology, five licensed speech-language pathologists, and five individuals who have experience communicating with

individuals diagnosed with ASD. Each participant shared their experience teaching conversational skills, as well as the number of years they have worked or interacted with individuals who have ASD. The majority (85%) of participants have directly addressed conversational skills in the past with a range of experience (< 1 year experience – 28 years).

Table 1

Results Pertaining to Participant Demographic Information

Question	Graduate Students	SLPs	Other
I am a ____ (graduate student, SLP, other).	10	5	Paraprofessional (1) Family Member (1) Occupational Therapist (1) Special Education Teacher (1) Direct Support Professional (1)
I have taught conversational skills in the past.	Yes (80%) No (20%)	Yes (100%) No (0%)	Yes (80%) No (20%)
If you have provided services to or interacted with individuals with ASD, how many years of experience do you have?	< 1 year (3) 1 year (2) 2 years (3) 3 years (1) 5 years (1) (mean: 1.6)	1 year 3 years 7 years 15 years 20+ years (mean: 9.2)	1 year 3 years 20 years 23 years 28 years (mean: 15)

Quantitative Data

Table 2 presents quantitative data from 5-point Likert scale responses detailing participant enjoyment while trialing the VR program. The number of participants who responded to each Likert scale rating is presented on the left with a corresponding percentage for the respective group provided in parentheses. All 20 participants (100%) reported they enjoyed the VR experience by selecting “strongly agree” or “agree” to the statement “I enjoyed the experience.”

Additionally, all (100%) graduate students shared that they "strongly agreed" or "agreed" with the statement "I enjoyed talking with the avatar." A total of 80% of SLPs and other professionals also "strongly agreed" or "agreed" they enjoyed talking to the avatar, while the remaining 20% in each group stated "neutral."

Participants in all three groups (100%) "strongly agreed" or "agreed" they enjoyed practicing the different parts of a conversation. Regarding earning points, 70% of graduate students, 80% of SLPs, and 80% of other professionals "strongly agreed" or "agreed" they enjoyed earning points throughout the experience. The remaining 20% of SLPs and other professionals stated "neutral."

Table 2

Results Pertaining to Participant Enjoyment

Question	Likert Scale Ratings	Graduate Students	SLPs	Other
I enjoyed the experience.	Strongly agree	5 (50%)	4 (80%)	2 (40%)
	Agree	5 (50%)	1 (20%)	3 (60%)
	Neutral	0 (0%)	0 (0%)	0 (0%)
	Disagree	0 (0%)	0 (0%)	0 (0%)
	Strongly disagree	0 (0%)	0 (0%)	0 (0%)
I enjoyed talking with the avatar.	Strongly agree	4 (40%)	2 (40%)	2 (40%)
	Agree	6 (60%)	2 (40%)	2 (40%)
	Neutral	0 (0%)	1 (20%)	1 (20%)
	Disagree	0 (0%)	0 (0%)	0 (0%)
	Strongly disagree	0 (0%)	0 (0%)	0 (0%)
I enjoyed practicing parts of a conversation.	Strongly agree	4 (40%)	2 (40%)	2 (40%)
	Agree	6 (60%)	3 (60%)	3 (60%)
	Neutral	0 (0%)	0 (0%)	0 (0%)
	Disagree	0 (0%)	0 (0%)	0 (0%)
	Strongly disagree	0 (0%)	0 (0%)	0 (0%)
I enjoyed earning points.	Strongly agree	7 (70%)	2 (40%)	3 (60%)
	Agree	3 (30%)	2 (40%)	1 (20%)
	Neutral	0 (0%)	1 (20%)	1 (20%)
	Disagree	0 (0%)	0 (%)	0 (%)
	Strongly disagree	0 (0%)	0 (%)	0 (%)

Table 3 provides participant responses regarding ease of interactions within the virtual environments. The number of participants who responded to each Likert scale rating is presented on the left with a corresponding percentage for the respective group provided in parentheses. Roughly 90% of graduate students, 60% of SLPs, and 100% of other professionals "strongly agreed" or "agreed" to the statement "it was easy to follow instructions for having a conversation," while the remaining participants stated "neutral."

Regarding avatar appearance and demeanor, 60% of graduate students, 40% of SLPs, and 60% of other professionals "strongly agreed" or "agreed" to the statement "the avatars seemed like real people." The remaining participants selected either "neutral" or "disagree."

Overall, the majority of the participants "strongly agreed" or "agreed" that it was easy to have a conversation with the avatars (70% of graduate students, 80% of SLPs, and 100% of other professional; other responses were "neutral").

Participants also selected ratings corresponding to the statement "the experience enhanced my conversational skills," with 80% of graduate students, 80% of SLPs, and 100% of other professionals stating they "strongly agreed" or "agreed" with the statement. The remaining graduate students (20%) selected "neutral" and one other professional (20%) selected "disagree." Approximately 90% of graduate students, 100% of SLPs, and 100% of other professionals "strongly agreed" or "agreed" with the statement "the conversational skills I learned in the virtual world will benefit me in the real world," with the remaining 10% of graduate students selecting "neutral."

Participants were asked to rate the user-friendliness of the program by rating the statement "the system was user-friendly," with 90% of graduate students, 60% of SLPs, and 60%

of other professionals stating “strongly agree” or “agree” and the remaining participants selected “neutral” or “disagree.”

Table 3

Results Pertaining to Interactions within the Virtual Environments

Question	Likert Scale Ratings	Graduate Students	SLPs	Other
It was easy to follow instructions for having a conversation.	Strongly agree Agree Neutral Disagree Strongly disagree	4 (40%) 5 (50%) 1 (10%) 0 (0%) 0 (0%)	1 (20%) 2 (40%) 2 (40%) 0 (0%) 0 (0%)	2 (40%) 3 (60%) 0 (0%) 0 (0%) 0 (0%)
The avatars seemed like real people.	Strongly agree Agree Neutral Disagree Strongly disagree	1 (10%) 5 (50%) 3 (30%) 1 (10%) 0 (0%)	0 (0%) 2 (40%) 1 (20%) 2 (40%) 0 (0%)	1 (20%) 2 (40%) 0 (0%) 2 (40%) 0 (0%)
It was easy to have a conversation with the avatars.	Strongly agree Agree Neutral Disagree Strongly disagree	3 (30%) 4 (40%) 3 (30%) 0 (0%) 0 (0%)	1 (20%) 3 (60%) 1 (20%) 0 (0%) 0 (0%)	1 (20%) 4 (80%) 0 (0%) 0 (0%) 0 (0%)
The experience enhanced my conversational skills.	Strongly agree Agree Neutral Disagree Strongly disagree	4 (40%) 4 (40%) 2 (20%) 0 (0%) 0 (0%)	1 (20%) 3 (60%) 0 (0%) 1(20%) 0 (0%)	1 (20%) 4 (80%) 0 (0%) 0 (0%) 0 (0%)
The conversational skills I learned in the virtual world will benefit me in the real world.	Strongly agree Agree Neutral Disagree Strongly disagree	4 (40%) 5 (50%) 1 (10%) 0 (0%) 0 (0%)	2 (40%) 3 (60%) 0 (0%) 0 (0%) 0 (0%)	3 (60%) 2 (40%) 0 (0%) 0 (0%) 0 (0%)
The system was user-friendly.	Strongly agree Agree Neutral Disagree Strongly disagree	4 (40%) 5 (50%) 1(10%) 0 (0%) 0 (0%)	0 (0%) 3 (60%) 1 (20%) 1(20%) 0 (0%)	0 (0%) 3 (60%) 1(20%) 1 (20%) 0 (0%)

Table 4 presents participant responses regarding the equipment used in this study. All (100%) participants “strongly agreed” or “agreed” that the instructions for using the equipment

were clear. Regarding the comfort of wearing the headset, 75% of participants (15) "strongly agreed" or "agreed" with the statement "the headset was comfortable," but 15% (3) responded "neutral" and 10% (2) responded "disagree."

Three (15%) of the participants reported they were affected by cybersickness throughout the VR experience. The majority (80%) of the participants "strongly agreed" or "agreed" they could wear the headset for 30 minutes or more at a time, but 5% (1) stated "neutral" and 15% (3) stated "disagree."

Lastly, all (100%) participants "strongly agreed" or "agreed" they would be willing to participate in therapy that used VR headsets if they had another opportunity.

Table 4

Results Pertaining to Equipment

Question	Likert Scale Ratings	Graduate Students	SLPs	Other
The instructions for using the equipment were clear.	Strongly agree Agree Neutral Disagree Strongly disagree	8 (80%) 2 (20%) 0 (0%) 0 (0%) 0 (0%)	3 (60%) 2 (40%) 0 (0%) 0 (0%) 0 (0%)	2 (40%) 3 (60%) 0 (0%) 0 (0%) 0 (0%)
The headset was comfortable.	Strongly agree Agree Neutral Disagree Strongly disagree	6 (60%) 2 (20%) 2 (20%) 0 (0%) 0 (0%)	2 (40%) 1 (20%) 1(20%) 1 (20%) 0 (0%)	1 (20%) 3 (60%) 0 (0%) 1 (20%) 0 (0%)
I was affected by cybersickness during the simulation.	Strongly agree Agree Neutral Disagree Strongly disagree	0 (0%) 2 (20%) 0 (0%) 3 (30%) 5 (50%)	0 (0%) 0 (0%) 0 (0%) 1 (20%) 4 (80%)	0 (0%) 1 (20%) 0 (0%) 0 (0%) 4 (80%)
I could wear the headset for 30 minutes or more at a time.	Strongly agree Agree Neutral Disagree Strongly disagree	2 (20%) 6 (60%) 1 (10%) 1 (10%) 0 (0%)	2 (40%) 2 (40%) 0 (0%) 1 (20%) 0 (0%)	1 (20%) 3 (60%) 0 (0%) 1 (20%) 0 (0%)
I would participate in therapy that	Strongly agree Agree	6 (60%) 4 (40%)	2 (40%) 3 (60%)	3 (60%) 2 (40%)

used virtual reality headsets if I had the opportunity again.	Neutral Disagree Strongly disagree	0 (0%) 0 (0%) 0 (0%)	0 (0%) 0 (0%) 0 (0%)	0 (0%) 0 (0%) 0 (0%)

Qualitative Data

Table 5 lists primary and secondary themes received from open-ended survey responses. Questions pertained to overall participant experience, perceived benefits for the ASD population, engagement, areas of improvement, and perceived use for professionals. Themes were iterative and developed by repeating patterns across participant responses. Qualitative data revealed 4 common themes among participants: (1) enjoyable experience, (2) virtual environments, (3) instruction, and (4) VR interest and application to intervention. A secondary theme of VR as a supplement to intervention was also disclosed. Further explanations and details of participant responses are provided.

Table 5

Results Pertaining to Common Themes among Qualitative Data

Primary Themes	Secondary Theme
Enjoyable Experience	VR as a Supplement to Intervention
Motivation for Adolescents with ASD	AI Implementation
Gamification to Support Engagement	
Confidence Increase	
Video Game Usage	
Virtual Environments	
Nature of VR Environments	
Avatar Appearance	
Instruction	
Visual Support	
Target Skills	
VR Interest and Application to Intervention	
Future Use	
Social Skills	

Enjoyable Experience

Out of 20 total participants, 14 (70%) indicated they had a fun and enjoyable experience while trialing the VR program. Participants conveyed thoughts regarding VR as a motivator for adolescents with ASD. One participant stated, “I think that the VR environment and rewards program would be great motivators for kids with autism.” Participants also expressed opinions regarding the gamification approach to intervention: “I have some older students who don't love explicit social skills instruction or practicing conversation with me. I think they'd be more willing to participate in something like this where it is more of a game.” Many participants discussed potential benefits of using VR with the ASD population as it has the potential to reduce pressure and anxiety while also building confidence by allowing the ASD user to feel more comfortable. One participant disclosed: “I think it would allow them to grow in conversation skills in a comfortable, judgement-free environment.” Additionally, 12 (60%) of the participants acknowledged that many adolescents, including individuals with ASD, enjoy playing video games and therefore may be attracted to the VR experience. The following is a statement provided by a participant regarding video game usage:

> *I think engagement is a huge factor in therapy for clients with ASD, and this really helps with that piece. Most children love video games, and this will make the feel of therapy less rigid and allow for more natural interactions.*

Virtual Environments

Regarding graphics of the program, 15 (75%) of the participants spoke about the visual appeal of the VR environments with one participant stating, “I really like the different environments and in the carnival level how they would have to try and find avatars to interact with (which makes it more of a game for them).” Another communicated, “I liked how all of the environments were different and each had unique features that will keep participants engaged.”

Although the environments were aesthetically pleasing, six of the 20 participants expressed concerns for the appearance of the avatars. One participant stated: “The graphics had some design errors that made them [the avatars] look angry or hovering, which may confuse a person with ASD,” and another recommended, “including more natural voices and appearances for the avatars may help the immersion of the system.

Instruction

When asked to provide feedback for improvement of the conversational instruction, four (20%) of the participants shared that ASD participants may benefit from more visual support during instruction (i.e., reading the instructions with the HMD as they are being provided by clinician, visual reminders of target skills, etc.). A participant further explained their reasoning: “The instructions might be a little lengthy for an individual with ASD to follow along with…they [visual cues] can be removed during conversation and provided again when cues are needed.” Another participant stated:

> *Conversation skills have a lot of components, and with ASD, visuals can help, so having something that lets you see the parts you need to do in the conversation on a panel to the side may help (to then fade as they improve).*

Participants were also asked to identify the skills that were most appropriate to target with the proposed VR program. Participants could provide multiple responses, with 16 (80%) stating topic maintenance, and nine (45%) asserting recognizing nonverbal cues that signal ‘wrap up.’ One participant provided feedback regarding appropriate target skills, but also explained why others may not work as well utilizing VR:

> *I think topic maintenance and turn-taking would be the best to target in a system like this. I think targeting eye gaze could be interesting, but it could be difficult to keep it naturalistic in*

a VR setting. I also think conversational markers (i.e., head nodding) could be tricky to target as there isn't a perfect number of conversational markers that should be present.

VR Interest and Application to Intervention

All 20 participants expressed their desire and interest to use VR during intervention and social skill training in the future. Participants found the VR program to possess many potential benefits for individuals with ASD, including being an engaging and motivating way to increase participation in conversational skills intervention. While there is great potential for VR intervention, one participant discussed some recommendations:

> *I think it could definitely be a new treatment method and could be a really beneficial avenue. I think it will probably be tricky ironing out the details especially keeping the ideals of neurodiversity in mind, but if used properly could be beneficial.*

A different participant stated: "I think it would be a great way to target social skills when you are unable to bring your client out into the community to practice."

Additionally, participants were asked to provide feedback regarding potential therapy applications for virtual reality simulations. Five of the 20 participants identified teaching personal space may be a beneficial intervention target for adolescents with ASD. An SLP stated, "I often got too close to the avatar by accident, but this could also be a good opportunity to talk about personal space and practice determining what is an appropriate amount of space to provide someone." In addition to personal space, three participants recommended practicing social scenarios using VR may be beneficial for individuals with ASD. Social scenarios may include practicing what it is like to go to a barber shop for a haircut, going to the dentist, or even identifying problems and solutions in social scenarios (e.g., the participant accidentally offends a conversation partner).

VR as a Supplement to Intervention

Although a less common theme, it is worth noting two participant opinions of VR as a supplement to intervention. One explained:

> *I believe that this experience could be beneficial for individuals with ASD…who already have some foundational social/conversational skills…I also think this [the VR program] would be beneficial if introduced after these [conversational] skills have been introduced in a typical clinical setting.*

Another participant spoke of the flexibility that VR may provide, especially for children who do not receive school-based services over summer break:

> *Yes, I think this could be a great addition to speech therapy…so have speech therapy in person and then virtual reality as a supplemental practice (e.g., over the summer if the clinician thinks the client will regress if not seen, to practice in [the]evening a couple nights a week after school). I think this is a wonderful opportunity for adolescents to grow in their conversation skills and [grow] in confidence in their ability to effectively communicate with others.*

AI Implementation

Three participants conveyed that they liked the inclusion of the AI feature as a generalization measure in the last environment, with one participant stating, “I think that the AI responses worked well and were a really cool feature.” An additional participant expressed:

> *It [the AI avatar] kept talking about the virtual world, which made it feel more like a computer game and less like practicing a real world conversation. Having the AI made it feel more like a conversation than the script.*

While some participants enjoyed interacting with the AI avatar, one individual expressed further concern: “I noticed when I was talking to the AI avatar, her responses didn't match up with what I said sometimes.”

Chapter 4: Discussion

Recent research development in allied health professions has included implementation of virtual reality into service delivery (e.g., Chard et al., 2023; Cote et al., 2023; Oliveira et al., 2020). Specifically, early forms of VR have been utilized with the ASD population to teach daily living skills and certain aspects of social skills (Mook & Ke, 2019; Zhang et al., 2022). The current study fills the gap in the literature with the development of a VR program intended to teach complex conversational skills to adolescents with ASD by utilizing an immersive VR head mounted display (i.e., Meta Quest Pro). The program also implemented a gamification approach, which Zhang et al. (2022) stated was a limitation of prior studies. Researchers received feedback on the VR program from individuals who have expertise communicating with people who have ASD. While the sample size of this study was limited to 20 participants, they each provided invaluable feedback that will aid researchers in further developing and improving the program before implementing the intervention with ASD participants.

Results from this study met the requirements for both proposed objectives. The first research objective of this study was to investigate the perceived applicability of virtual reality as a speech-language therapy tool. Results suggest that SLPs and other professionals who have experience communicating with individuals diagnosed with have ASD feel they could implement the VR intervention into their sessions. Research by Chard et al. (2023) and Chiu et al. (2022) also supports this notion that VR may be applicable in the field of speech-language pathology as well. All skills targeted in this study were viewed as appropriate intervention skills; however,

some participants stated they felt the nonverbal acknowledger task felt unnatural the way in which the target skills was presented with the VR environment. Across all three groups of participants (i.e., SLP grad students, SLPs, and other professionals), it was noted that topic maintenance skills were perceived to be the most beneficial skill to target with the proposed VR program. Participants also provided recommendations for future therapy applications using VR. Skills that may benefit from the use of VR social skill intervention may include practicing social scenarios (e.g., what happens when a person gets their haircut, goes to the dentist, etc.), recognizing personal space, and identifying problems and solutions in social contexts (e.g., the person with ASD accidentally offends a conversation partner). Of importance, 100% of the participants expressed they would be interested in utilizing VR intervention in the future and they recognize the potential benefits of virtual reality as an emerging technology.

The second research objective was to evaluate the perceived usability of a virtual reality simulation to teach conversational skills to adolescents with ASD. The results suggest that there is strong potential for VR as a social skills intervention. This aligns with previous research asserted by Ip et al. (2022). While there is evident potential, the current system requires further development to maximize its effectiveness. Participants stated that the system, as it was shown to them, would be strengthened with inclusion more natural avatars and easier navigation in environments. Regarding instruction, many participants recommended changes to prevent adolescents with ASD from becoming distracted during instruction. Additionally, speech-language pathology clinicians felt that the cueing hierarchy could be improved by providing visual supports (e.g., reminders of conversational components, choices for acknowledgers, written instruction); however, they appreciated that the cueing provided was non-judgmental and direct. The majority of the participants also expressed that there is potential for adolescents with

ASD to benefit from using the system because they may feel more comfortable practicing conversational skills. One participant described the VR simulation as a “low-stakes” environment that may reduce pressure, fear of peer rejection, and anxiety. Likewise, Bellani et al. (2011) also describes VR environments as a safe environment to practice conversational skills. Additionally, participants stated that reinforcers such as earning coins and playing games will aid in motivation and engagement during intervention. This coincides with the argument provided by Zhang et al. (2022) that gamification can improve motivation, attention, and focus of the ASD participant.

Chapter 5: Limitations and Future Directions

There are several limitations to this study with the first being that this research was a pilot study with neurotypical adults. Researchers designed the VR program for adolescents diagnosed with ASD, however none of the participants in the current study had an ASD diagnosis. Participants were encouraged to utilize responses characteristic of an individual with ASD, and although many provided appropriate examples of autistic tendencies, no behaviors were a true representation of an individual with ASD. The second limitation is that the participants were also recruited from a convenience sample. Many were graduate students, faculty, or alumni of the university in which the study was conducted, so many may have had similar learning experiences regarding the assessment and treatment of ASD. Additionally, participants were from one geographic location and may have similar word views, experiences, and beliefs. Lastly, the VR program is still in its early development. Aspects such as gamification approaches, cueing hierarchies, data tracking, graphics, and AI implementation need further refinement. Participants may have had different opinions regarding the applicability and usability of the VR program if

all developments had been implemented and polished prior to the participants trialing the program.

In the future, researchers plan to implement a video replay feature to review participant behaviors and allow SLPs to provide relevant feedback. Cueing hierarchies will be improved to include visual choices of appropriate responses participants can use should they need cueing to continue the conversation. Additionally, instruction of conversation components will also be presented visually for the participants with ASD to read along as the script is read aloud. Inclusion of the video replay feature, visual choices, and visual instructions will reinforce the feedback from participants indicating that the program required additional visual support. Furthermore, the avatars will undergo improvement to display a more welcoming and friendly appearance since some participants stated the demeanor of the current avatars may scare or confuse people with ASD. A future study will analyze the effectiveness of the VR intervention with adolescents diagnosed with ASD after implementing feedback received from the current study.

Chapter 6: Conclusion

The results of this study indicate there is strong potential of VR utilization for social skills training in speech-language pathology intervention. Regarding applicability, professionals in the field and others who have experience with the ASD population appear to be very interested in the application of VR into service delivery. Secondly, participants found the overall usability of the VR program to be positive as may were satisfied with the ease of use, the way in which the conversational skills instruction was provided, as well as the potential for VR to be used as an outlet to practice conversation. While the results of this study are promising, further research

is required to understand the effectiveness of VR intervention as researchers continue to develop and refine the emerging technology.

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Appendix A

Instructions for Equipment Use

“I am going to provide you with instructions about how to use the equipment we will be using for your virtual reality experience.”

“Pick up the headset from the back strap. Pull and extend the head strap so that the opening is large enough to fit comfortably on your head.”

“Lower the headset and align the viewport with your eyes.”

“Adjust the fit of the headset so that it fits snuggly on your head without being overly tight using the knob on the back of the headset.”

“Throughout the VR experience, you will utilize these two Meta Touch controllers to interact with elements of the virtual world.”

“The investigator/clinician will provide instructions for using the controllers as they become relevant throughout the experience.”

“As a reminder, if at any time you feel uncomfortable or sick, you are free to remove the headset and take a break.”

“If you are comfortable with the equipment, we can begin our experience. Are you ready?”

Appendix B

VR Environments

Figure 2

Lake Environment

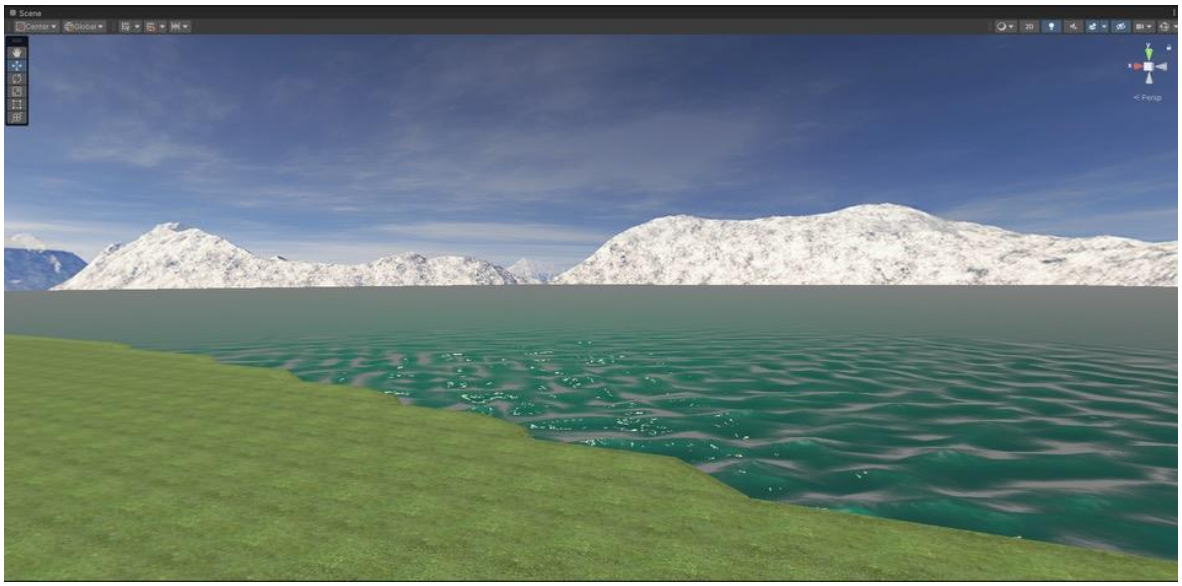

Figure 3

Bowling Alley Environment

Figure 4

Classroom Environment

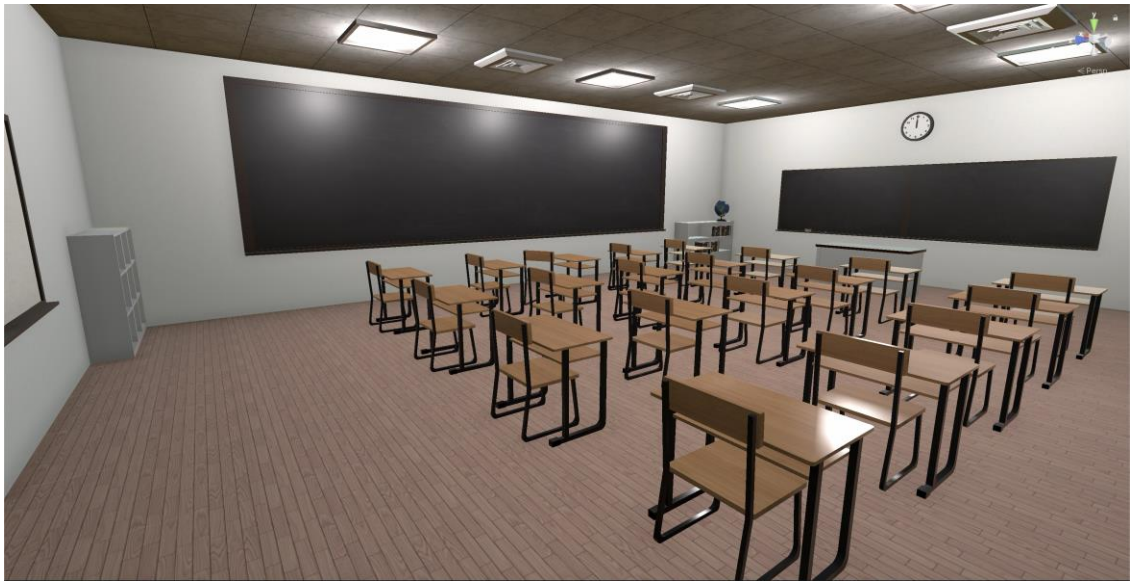

Figure 5

Carnival Environment

Appendix C

Environment 1 Script/Data Sheet

"Today you will be entering five virtual environments. While we play the game, you will practice your conversation skills by completing missions. You can see that we are at a lake right now, and there are a few people here. I would like for you to walk over and have a conversation with the person closest to you. When you are finished, come back to get your coin!"

When the participant returns to the researcher's avatar, they will be awarded one coin. Then they will be asked to approach the next avatar and have a conversation.

"Awesome! I would like you to have a conversation with another person. When you are finished, come back and get your coin!"

When the participant returns to the researcher's avatar, they will be awarded one coin. Then they will be asked to approach the third and final avatar and have a conversation.

"You are doing great! I would like you to have another conversation with the last person here."

After the participant has had a conversation with three avatars, they can play a fishing game by using their coins.

"Congratulations! Let's count your coins. For every coin you've earned, you get that many turns fishing. You can spend them now!"

"You are doing an excellent job following instructions. Let's go to the next world and practice some more!"

Maximum coins that can be earned: 3

1 coin = 1 turn

	Trial 1	Trial 2	Trial 3	Total
Greeting	/1	/1	/1	/3
Small talk	/1	/1	/1	/3
Nonverbal acknowledgers with nonpreferred story (Award 1 point if nonverbal acknowledgers	/1	/1	/1	/3

were used at least one time.)				
Topic maintenance with nonpreferred topic – asking questions and making comments (Award 1 point if at least four on-topic turns were taken.)	/1	/1	/1	/3
Topic maintenance with nonpreferred topic – eye gaze (Award 1 point if participant shifted gaze toward conversation partner's face at least one time.)	/1	/1	/1	/3
Recognizing cues to 'wrap up'	/1	/1	/1	/3
'Wrap up'	/1	/1	/1	/3
Farewell	/1	/1	/1	/3

Appendix D

Environment 2 Script/Data Sheet

"Woah! Now we are at the bowling alley! Let's see who is here."

"We are going to work on our conversation skills. This will help us interact with others, better understand conversation, and make friends."

- Greeting:
  - "Are you ready for mission one? Your mission is to use greetings."
  - "Every good conversation starts with a greeting."
  - "'Hi,' 'hello,' and 'how are you?' are greetings. If you are with a friend, you may even say 'What's up?' or 'How's it going?'"
  - "Tell me another greeting you think you could use with a friend."
  - **Wait for participant's response.**
    - **If response is appropriate –** "Terrific!" **Continue with script.**
    - **If response is not appropriate or no response –** "You can say 'hey' to greet someone."
  - "Mission accomplished." **Award coin if appropriate.**
  - "Are you ready for mission two?"

- Small talk:
  - "Your mission is to use small talk. Sometimes before you ask someone for something or tell someone something important, you will talk about everyday things that are less important. This is a warmup."
  - "Small talk can be about things like the weather outside, complimenting someone, or asking how someone's day has been so far. Tell me another example of something you could say for small talk."
  - **Wait for participant's response.**
    - **If response is appropriate –** "Excellent!" and continue with next skill.
    - **If response is not appropriate or no response –** "We can say things like 'do you have anything fun planned for the weekend?' Try that one." **Continue with the next skill.**
  - "Mission accomplished." **Award coin if appropriate.**
  - "Are you ready for mission three?"

- Nonverbal Acknowledgers when listening to a non-preferred story:
  - "Your mission is to show others you are listening by nodding your head or saying 'mhm.' When someone tells a story, it is important we show we are listening to them."
  - "Even if you're not interested in what they are talking about, it is still important to show you are listening."
  - "You can nod your head or say 'mhm' to let the person know that you are paying attention, especially when it is about a topic you don't like."

    - "Now I am going to tell you a short story and I would like you to nod your head or say 'mhm' every time I pause."
    - "Here is a fun fact about me. I like learning about government processes. (pause)
        - **If response is appropriate –** Continue with script.
        - **If response is not appropriate or no response –** "Remember to show me you are listening by nodding your head or saying 'mhm'."
    - "Everyone can register to vote when they are 18 years old." (pause)
        - **If response is appropriate –** Continue with script.
        - **If response is not appropriate or no response** – "Remember to show me you are listening by nodding your head or saying 'mhm'."
    - "It is every citizen's responsibility and duty to vote so they can voice their opinion to the government." (pause)
        - **If response is appropriate –** Continue with script.
        - **If response is not appropriate or no response –** "Remember to show me you are listening by nodding your head or saying 'mhm'."
    - "During the presidential election of 2008, Barack Obama was elected as the 44th president." (pause)
        - **If response is appropriate** – Continue with script.
        - **If response is not appropriate or no response –** "Remember to show me you are listening by nodding your head or saying 'mhm'."
    - "He was the first African American president of the United States." (pause)
        - **If response is appropriate –** Continue with script.
        - **If response is not appropriate or no response –** "Remember to show me you are listening by nodding your head or saying 'mhm'."
    - "What is a fun fact about you or what do you like learning about?"
        - "Cool!" **Continue to the next skill.**
    - "Mission accomplished." **Award coin if appropriate.**
    - "Are you ready for mission four?"

- Topic maintenance of non-preferred topic (including asking questions, making comments, and eye gaze):
    - Taking turns by asking questions and making comments (goal = minimum of 4 turns)
        - "Your mission is to take turns by asking questions or making comments."
        - "Instead of nodding or saying 'mhm,' you might want to be more active in the conversation. You can ask a question or make a comment about what the other person said."
        - "We ask questions to find something out. If the other person says, 'I'm hungry,' you could ask something like 'what kind of food are you in the mood for?'"
        - "You can also make a comment. A comment is when you just say something back about what the person has said. If you told me 'I love pizza,' I could make a comment by saying 'Oh me too! Pepperoni is my favorite.'"
        - "When you ask a question or comment, it needs to be on the same topic as what the person said."

- "Let's practice."
- "I recently went to the botanical gardens in Pittsburgh."
  - **If response is appropriate –** Continue with script.
  - **If response is not appropriate or no response –** "You can ask me a question about what I said or make a comment. You can say something like 'I like Pittsburgh.' Try again!"
  - **Respond to what participant said (e.g., "That was a great question!") and continue with script.**
- "There were different types of flowers from many countries." (pause)
  - **If response is appropriate –** Continue with script.
  - **If response is not appropriate or no response –** "You can ask me a question about what I said or make a comment. You can something like 'What kinds of flowers?'"
  - **Respond to what participant said (e.g., "That was a great question!") and continue with script.**
- "The botanical garden was decorated with Christmas lights, and we took lots of pictures." (pause)
  - **If response is appropriate –** Continue with script.
  - **If response is not appropriate or no response –** "You can ask me a question about what I said or make a comment. You can say something like, 'I love looking at Christmas lights'."
  - **Respond to what participant said (e.g., "That was a great question!") and continue with script.**
- "It was very cold that night, so went for hot chocolate afterwards." (pause)
  - **If response is appropriate –** Continue with script.
  - **If response is not appropriate or no response –** "You can ask me a question about what I said or make a comment. You can say something like 'Do you like marshmallows on your hot chocolate?'"
  - **Respond to what participant said (e.g., "That was a great question!") and continue with script.**
- "I really enjoyed my trip to Pittsburgh.
  - **If response is appropriate –** Continue with script.
  - **If response is not appropriate or no response –** "You can ask me a question about what I said or make a comment. You can say something like 'Sounds like you had a good time!'"
  - **Respond to what participant said (e.g., "That was a great question!") and continue with script.**
- Have you been on any trips recently?"
  - **Respond to what participant said and continue with script.**
- "Mission accomplished." **Award coin if appropriate.**
- "Are you ready for mission five?

- Eye gaze when listening to a nonpreferred story

- "Your mission is to show you are listening by looking toward the person when they talk."
- "When we have a conversation, we should look toward each other. It's okay to look away occasionally, but you should at least glance at them every now and again. This lets them know you are paying attention."
- "Usually you look in the general direction of their face at least once for each turn they take."
- "Let's practice."
- "I have many relatives including three aunts and uncles, seven cousins, and two sets of grandparents, but my favorite relative is my grandpa." (pause)
    - **If response is appropriate –** Continue with script.
    - **If response is not appropriate or no response –** "Remember to look toward my face at least once every turn I take."
- "He was a teacher and taught for many years in the public schools, but now he is retired." (pause)
    - **If response is appropriate –** Continue with script.
    - **If response is not appropriate or no response –** "Remember to look toward my face at least once every turn I take."
- "He was raised in a small town and lived on a farm with his parents, brothers, and sisters." (pause)
    - **If response is appropriate –** Continue with script.
    - **If response is not appropriate or no response –** "Remember to look toward my face at least once every turn I take."
- "When I visit my grandpa, I like to play Rummy, go for walks, and go out to eat at Red Robin." (pause)
    - **If response is appropriate –** Continue with script.
    - **If response is not appropriate or no response –** "Remember to look toward my face at least once every turn I take."
- "My grandpa taught me how to ride a bike." (pause)
    - **If response is appropriate –** Continue with script.
    - **If response is not appropriate or no response –** "Remember to look toward my face at least once every turn I take."
- "Who's your favorite relative?"
    - **Respond to what participant said and continue with script.**
- "Mission accomplished." **Award coin if appropriate.**
- "Are you ready for mission six?

- Recognizing cues to 'wrap up:'
    - "Your mission is to recognize when a person is finished talking about something.
    - "It is important we pay attention to a person's body language to understand if they are finished with the conversation."
    - "If you see a person look away more often, move farther away from you, or turn their body away from you, it probably means they want to end the conversation. Then you will know it is time to wrap the conversation up."

    - "Now I want you to tell me a story about yourself. I will show you when I'd like to end the conversation by looking away more often, moving farther away from you, or turning my body away from you. When you notice, raise your hand."
    - "Tell me about your favorite movie."
        - **If the participant raises their hand at the appropriate time –** Continue with script.
        - **If the participant doesn't raise their hand at the appropriate time –** "Remember to watch if I look away more frequently, move farther away from you, or turn my body away from you. Let's do that again, and I will raise my hand with you when you notice I am ready to end the conversation." **Continue with script.**
    - "Mission accomplished." **Award coin if appropriate.**
    - "Are you ready for mission seven?"

- 'Wrap up:'
    - "Your mission is to wrap a conversation up."
    - "When you notice someone is interested in ending the conversation, you can insert a 'wrap up.' This is so the conversation doesn't end so suddenly."
    - "Examples of wrapping up may be 'I better get going,' 'thanks for chatting with me,' or 'it was great to meet you.'"
    - "Tell me another way you might 'wrap up' a conversation?"
        - **If response is appropriate –** "Excellent!" **Continue with script.**
        - **If response is not appropriate or no response –** "We can say things like 'okay, I'll let you go. Try that out'." **Continue with script.**
    - "Mission accomplished." **Award coin if appropriate.**
    - "Are you ready for mission eight?"

- Farewell
    - "Your mission is to end a conversation."
    - "After you signal the end of a conversation by wrapping things up, it is time to say goodbye."
    - "You can say 'bye,' 'see you later,' or 'talk to you soon.'"
    - "Tell me another way to say goodbye."
        - **If response is appropriate –** "Excellent!" **Continue with script.**
        - **If response is not appropriate or no response –** "We can say things like 'have a good day' to end a conversation."
    - "Mission accomplished." **Award coin if appropriate.**

"Congratulations! Let's count your coins. Now you can use your coins to play a game of bowling! For every coin you've earned, you get that many turns bowling. You can spend them now!"

"Are you ready to teleport to the next world so you can complete these missions with other people we meet? I'll still be here to help you along the way."

Maximum coins that can be earned: 8

1 coin = 1 turn

	Trial 1
Greeting	/1
Small talk	/1
Nonverbal acknowledgers with nonpreferred story (Award 1 point if nonverbal acknowledgers were used at least one time.)	/1
Topic maintenance with nonpreferred topic – asking questions and making comments (Award 1 point if at least four on-topic turns were taken.)	/1
Topic maintenance with nonpreferred topic – eye gaze (Award 1 point if participant shifted gaze toward conversation partner's face at least one time.)	/1
Recognizing cues to 'wrap up'	/1
'Wrap up'	/1
Farewell	/1

Appendix E

Environments 3 Script/Data Sheet

"Now we are in a classroom at school. It looks like there is some time before class starts. Let's talk to a few people!"

"Remember the important components of a conversation when you begin talking to the next person: greeting, small talk, showing you are listening, asking questions, making comments, looking at the other person, body language that signals the end of a conversation, 'wrap up,' and farewell.

"You will have five new missions. They are like the ones before, but now you will have a conversation with five different people."

- Avatar 1
  - "Your mission is to have a conversation to practice everything you learned in the last world."
  - Greeting and Small Talk
    - "The first part of your mission is to greet and have small talk with the first person. When you're finished, come back to get your coin!"
    - **If response is appropriate –** "Excellent!" and **continue with next skill.**
    - **If response is not appropriate or no response –** "We can say things like 'Hi! Do you have anything fun planned for the weekend?' Try that one with the same person." **Participant should return to avatar. Award coin if appropriate. Continue with script.**
  - Nonverbal Acknowledgers
    - "The next part of your mission is to nod your head or say 'mhm' to show you are listening when there is a pause."
    - "Go back to the same person and try it out."
    - Avatar script: "The Dewey Decimal System is a way to organize books in a library. (pause) People began using this system in 1873. (pause) The books are organized by the group they belong to like science, religion, or language (pause). This system helps people to find the book they want to read much faster than going through each book one at a time. (pause) Believe it or not, The Dewey Decimal System is still used today!" (pause)
    - **If responses were appropriate –** "Excellent!" and **continue with next skill.**
    - **If responses were not appropriate or no response –** "When there is a pause in a conversation, you can nod your head or say 'mhm' to show me you are listening. Try that out with the same person."
    - **Participant should return to avatar. Award coin if appropriate. Continue with script.**
  - Topic Maintenance of Non-Preferred Topic
    - Taking Turns by Asking Questions and Making Comments

- "The next part of your mission is to take turns by asking questions or making comments that are on topic when there is a pause."
- "If the other person says, 'I'm hungry,' what question could you ask me?"
- **If response is appropriate –** "Excellent!" and **continue with script.**
- **If response is not appropriate or no response –** "You could ask something like 'what kind of food are you in the mood for?'"
- If the person says, 'I love pizza,' what comment could you make?
- **If response is appropriate –** "Excellent!" and **continue with script.**
- **If response is not appropriate or no response –** "You could say 'Oh me too! Pepperoni is my favorite.'
- "Let's practice again with the same person."
- Avatar script – "My favorite movie is Finding Nemo. (pause). Nemo is a clownfish who gets lost from his dad, Marlin. (pause) Marlin makes a friend named Dory and together they work to find Nemo. (pause) The movie shows all of Nemo's adventures to get back to his dad. (pause) I think I like that movie because there is a happy ending." (pause)
- **If responses were appropriate –** "Excellent!" and **continue with next skill.**
- **If responses were not appropriate or no response –** "When there is a pause in a conversation, you can ask a question or make a comment about the same topic."
- **Participant should return to avatar. Award coin if appropriate. Continue with script.**

▪ Eye Gaze

- "The next part of your mission is to show you are listening by looking toward the person when they talk."
- "Remember when you are talking to someone, look toward them. It's okay to look away occasionally, but you should at glance at them at least once for every turn they take."
- Avatar Script – "I have always liked to bake since I was young. (pause) My mother taught me how to make homemade peanut butter cookies for Christmas. (pause) The recipe is simple because it only requires three ingredients: peanut butter, sugar, and an egg. (pause) Combine one cup of peanut butter and one cup of sugar, then add an egg to moisten the dough and hold it together. (pause) Bake them for 10 minutes at 350 degrees, let them cool, and enjoy! (pause)
- **If participant uses appropriate eye gaze –** Excellent!" and **continue with next skill.**

- **If participant does not use appropriate eye gaze –** "Remember to look toward the person's face at least once every turn the take. Try it again with the same person."
- **Participant should return to avatar. Award coin if appropriate. Continue with script.**

- Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
  - "The next part of your mission is to recognize when a person is finished talking about something, wrap a conversation up, and end a conversation with a farewell."
  - "Remember, if you see a person look away more often, move farther away from you, or turn their body away from you, it probably means they want to end the conversation. Then you will know it is time to wrap the conversation up and say a farewell."
  - "Tell the avatar about your favorite animal."
  - **If response is appropriate –** "Excellent!" and **continue with next skill.**
  - **If response is not appropriate or no response –** "We look to see if the person looks away more often, moves farther away from you, or turns their body away from you. Then we say something to wrap the conversation up like 'it was good talking to you' and then we can say farewell like 'bye.' Try that one with the same person."
  - **Participant should return to avatar. Award coin if appropriate. Continue with script.**
  - "Mission accomplished. We'll try this again with the next person."

- Avatar 2
  - Greeting and Small Talk
    - Same script as with Avatar 1
  - Nonverbal Acknowledgers
    - Same script as with Avatar 1
    - Avatar Script – "My sister enrolled in a ballet class when she was just four years old. (pause) My mother thought it would be a good way for her to make friends and socialize with kids her age. (pause) After the first class, she instantly fell in love with the art of ballet. (pause) She got a scholarship to study ballet at an arts school. (pause) Now my sister lives in New York City and is a professional ballet dancer." (pause)
  - Topic Maintenance of Non-Preferred Topic
    - Taking Turns by Asking Questions and Making Comments
      - Same script as with Avatar 1
      - Avatar Script – "I recently applied for a job at Texas Roadhouse to be a server. (pause) I need a job to save money to buy a house. (pause) The application was easy to complete, but the manager contacted me about coming in for an interview. (pause) I am nervous because I don't know what the manager will ask me. (pause) My father told me he would help me prepare by asking practice interview questions." (pause)
    - Eye Gaze

                - Same script as with Avatar 1
                - Avatar Script – “When I was in high school, I was a member of the marching band. (pause) I played the clarinet, which is a woodwind instrument. (pause) In the fall, we always competed in band competitions every Saturday. (pause)The marching band also went on a few trips, and we even got to play in a parade at Disney World! (pause) Being in the marching band allowed me to have fun and make many new friends.” (pause)
        - Recognizing Cues to ‘Wrap Up,’ ‘Wrap Up,’ and Farewells
            - Same script as with Avatar 1
            - Conversation topic – “Talk about your favorite restaurant and what you order.”
- Avatar 3
    - Greeting and Small Talk
        - Same script as with Avatar 1
    - Nonverbal Acknowledgers
        - Same script as with Avatar 1
        - Avatar Script – “I always loved going on field trips during elementary school. (pause) In the second grade, my class went to a history museum near my house. (pause) We learned what it was like to live before there people had electricity. (pause) We even learned how to churn our own butter. (pause) It is fun to learn about history and what it was like to live in the past.” (pause)
    - Topic Maintenance of Non-Preferred Topic
        - Taking Turns by Asking Questions and Making Comments
            - Same script as with Avatar 1
            - Avatar Script – “Egypt is a country located in northern Africa. (pause) The Egyptian people are known for their writing system known as hieroglyphics. (pause) The people are also famous for their beautiful architecture including pyramids, temples, and monuments. (pause) The longest river in the world, The Nile River, also runs through Egypt. (pause) Many tourists visit Egypt for its beauty and history.” (pause)
        - Eye Gaze
            - Same script as with Avatar 1
            - Avatar Script – “Every four years, countries from all over the world complete in the Summer Olympics. (pause) The first Olympics were held in Athens, Greece, but now the location varies. (pause) The 2024 Summer Olympics will be held in Paris, France. (pause) Athletes compete in various sports including volleyball, swimming, gymnastics, and many more. (pause) I always look forward to watching the games on television!” (pause)
    - Recognizing Cues to ‘Wrap Up,’ ‘Wrap Up,’ and Farewells
        - Same script as with Avatar 1
        - Conversation topic – “Describe a vacation you have been on.”

- Avatar 4
    - Greeting and Small Talk
        - Same script as with Avatar 1
    - Nonverbal Acknowledgers
        - Same script as with Avatar 1
        - Avatar Script – "Photosynthesis is the way plants make food for themselves. (pause) The plants need sunlight, water, and carbon dioxide to complete this process. (pause) Plants absorb sunlight from their leaves, water from their roots, and carbon dioxide from the air. (pause) Plants are the foundation and a vital component of all food webs. (pause) Photosynthesis is an amazing process that we all take for granted." (pause)
    - Topic Maintenance of Non-Preferred Topic
        - Taking Turns by Asking Questions and Making Comments
            - Same script as with Avatar 1
            - Avatar Script – "Every summer, my family raises a big garden. (pause) We plant squash, tomatoes, cucumbers, potatoes, beans, and corn. (pause) Sometimes it is a lot of work to maintain a garden because you must pull weeds and water the plants every day. (pause) Even though it is challenging work, harvesting the vegetables is a great reward. (pause) I personally think homegrown vegetables taste better than those that you buy at a grocery store." (pause)
        - Eye Gaze
            - Same script as with Avatar 1
            - Avatar Script – "Michael Jordan is arguably the best basketball player of all time. (pause) He is most known for playing for the Chicago Bulls. (pause) His career lasted for a total of 15 seasons, and he scored over 32,000 points. (pause) He also has his own shoe line with Nike called "Jordans." (pause) Many young basketball players consider Michael Jordan to be a hero." (pause)
    - Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
        - Same script as with Avatar 1
        - Conversation topic – "Tell the person about things you like."
- Avatar 5
    - Greeting and Small Talk
        - Same script as with Avatar 1
    - Nonverbal Acknowledgers
        - Same script as with Avatar 1
        - Avatar Script – There are many Spanish speaking countries including Costa Rica, Mexico, and Argentina. (pause) Even though these countries all speak Spanish, they each have their own variations called a dialect. (pause) When I go to college, I think it would be cool to study abroad in a Spanish speaking country. (pause) I know the universities in this area have students who travel to Spain and stay for the whole semester. (pause)

Being immersed in the culture would help me learn Spanish quicker!" (pause)

- Topic Maintenance of Non-Preferred Topic
  - Taking Turns by Asking Questions and Making Comments
    - Same script as with Avatar 1
    - Avatar Script – "Everyone needs a good hobby to help pass the time when they are bored. (pause) There are many different hobbies such as knitting, playing sports, painting, or even cooking. (pause) There are many great hobbies, but my favorite is wood working. (pause) I like to take wood from old and abandoned barns and make decorations to sell. (pause) Not only do I get to have fun making new things, but I can earn money too!" (pause)
  - Eye Gaze
    - Same script as with Avatar 1
    - Avatar Script – "I like to grow different house plants at my home. (pause) My favorite plants to grow are succulents. (pause) I like succulents because you don't have to water them often. (pause) This is good for me because I tend to forget about the plants. (pause) Succulents are great for people who don't have a green thumb because they are low maintenance plants." (pause)
- Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
  - Same script as with Avatar 1
  - Conversation topic – "Talk about your favorite holiday and how you celebrate it."

"Congratulations! Let's count your coins. Now you can use your coins to take field trips! Each trip costs 10 coins. Where will you go? Here are your choices: the moon, a volcano, or Antarctica.

"Are you ready to teleport to the next world so you can complete these missions with other people we meet? I'll still be here to help you along the way."

Maximum coins that can be earned: 25

7 coins = 1 trip

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Total**
Greeting	/1	/1	/1	/1	/1	/5
Small talk	/1	/1	/1	/1	/1	/5
Nonverbal acknowledgers with nonpreferred	/1	/1	/1	/1	/1	/5

story (Award 1 point if nonverbal acknowledgers were used at least one time.)						
Topic maintenance with nonpreferred topic – asking questions and making comments (Award 1 point if at least four on-topic turns were taken.)	/1	/1	/1	/1	/1	/5
Topic maintenance with nonpreferred topic – eye gaze (Award 1 point if participant shifted gaze toward conversation partner's face at least one time.)	/1	/1	/1	/1	/1	/5
Recognizing cues to 'wrap up'	/1	/1	/1	/1	/1	/5
'Wrap up'	/1	/1	/1	/1	/1	/5
Farewell	/1	/1	/1	/1	/1	/5

Appendix F

Environments 4 Script/Data Sheet

“Now we are at a carnival. Let’s talk to the others who are here.”

“Remember the important components of a conversation when you begin talking to the next person: greeting, small talk, showing you are listening, asking questions, making comments, looking at the other person, body language that signals the end of a conversation, ‘wrap up,’ and farewell.”

“Now you have five more missions: have a conversation with five new people.”

- Avatar 6
  - “Your mission is to have a conversation to practice the everything you learned in the last world.”
  - Greeting and Small Talk
    - Same script as with Avatar 1
  - Nonverbal Acknowledgers
    - Same script as with Avatar 1
    - Avatar Script – “My dad never passes up a great deal when he sees something on sale. (pause) We always go shopping on Black Friday and my family members have a competition to see who saves the most money. (pause) Last year, my dad was convinced he was going to win the contest. (pause) He ended up saving $500 on a 70 inch flat screen TV he bought from Walmart. (pause) He may have won this time, but next year, the competition will be mine!” (pause)
  - Topic Maintenance of Non-Preferred Topic
    - Taking Turns by Asking Questions and Making Comments
      - Same script as with Avatar 1
      - Avatar Script – “Many children love attending camp during their summer break. (pause) Some camps allow kids to learn about the outdoors, while others focus on the arts. (pause) Some campers stay overnight, while others may only attend during the day. (pause) Going to summer camp is a wonderful way to make friends and build character. (pause) Most importantly, you can make memories that will last a lifetime!” (pause)
    - Eye Gaze
      - Same script as with Avatar 1
      - Avatar Script – “Some parents may choose to homeschool their children. (pause) Kids may be homeschooled to have a more personalized education. (pause) The parents can also provide more attention to their child’s learning. (pause) Homeschooling can be a lot of work for the parents, but the benefits often outweigh the

challenges. (pause) The current trends show that homeschooling rate will continue to rise in the future." (pause)

- Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
  - Same script as with Avatar 1
  - Conversation topic – "Talk about a game to play."

- Avatar 7
  - Greeting and Small Talk
    - Same script as with Avatar 1
  - Nonverbal Acknowledgers
    - Same script as with Avatar 1
    - Avatar Script – "When I was a young child, I wanted to be a veterinarian when I grew up. (pause) I always loved taking care of animals and playing with them. (pause) My dream is to have my own farm so I can have all the animals I want! (pause) I hope to have chickens, sheep, cows, and horses. (pause) I know it will be a big task to take care of all the animals, but I will be doing what I love!" (pause)
  - Topic Maintenance of Non-Preferred Topic
    - Taking Turns by Asking Questions and Making Comments
      - Same script as with Avatar 1
      - Avatar Script – "Someone once asked me what rules I would have for my children if I was a parent. (pause) That was a difficult question to answer because I had never thought about it. (pause) The first rule I would have for my kids is that they each must do at least one chore per day. (pause) By everyone pitching in on the housework, we will have more time to relax and enjoy our time together. (pause) I think it is important for children to have chores to prepare them for adulthood when they are on their own." (pause)
    - Eye Gaze
      - Same script as with Avatar 1
      - Avatar Script – "I am trying to find a new hobby to occupy my time when I am bored. (pause) My friend suggested I work puzzles, but I am not sure that is the right hobby for me. (pause) My mom mentioned that I could learn how to knit, but that seems time consuming. (pause) I might try photography because I have always enjoyed taking photos and editing them. (pause) If everything goes well, I could even start my own business and make money!" (pause)
  - Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
    - Same script as with Avatar 1
    - Conversation topic – "Talk about the things you like to do on a lazy day."

- Avatar 8
  - Greeting and Small Talk
    - Same script as with Avatar 1
  - Nonverbal Acknowledgers
    - Same script as with Avatar 1

        - Avatar Script – “During my first year of college, I enrolled in a psychology course. (pause) Psychology is the study of mental processes and behavior. (pause) Significant scholars in this field include Freud, Piaget, and Skinner. (pause) There are many subtopics of psychology like clinical psychology, social psychology, and cognitive psychology. (pause) I look forward to learning more about psychology and the many theories that attempt to explain human behavior.” (pause)
    - Topic Maintenance of Non-Preferred Topic
        - Taking Turns by Asking Questions and Making Comments
            - Same script as with Avatar 1
            - Avatar Script – “There are many things I hope to learn throughout my lifetime (pause) Some people may want to learn how to play the guitar, ride a bike, or raise a garden. (pause) I want to learn how to create my own website and share monthly blogs about my experiences. (pause) It will take a lot of research to learn how to make a website, because I don’t know much about technology. (pause) I love learning new things, so I think I will be a lifelong learner.” (pause)
        - Eye Gaze
            - Same script as with Avatar 1
            - Avatar Script – “Charles Darwin is one of many great scholars in the field of biology. (pause) He is known for his theories regarding evolution and natural selection. (pause) Darwin argued that species evolve over time through a process called natural selection. (pause) Natural selection is the idea that species will change over time by passing on the most desirable traits during reproduction. (pause) Darwin’s theories are still being taught around the world today.” (pause)
    - Recognizing Cues to ‘Wrap Up,’ ‘Wrap Up,’ and Farewells
        - Same script as with Avatar 1
        - Conversation topic – “Talk about your favorite place to go.”
- Avatar 9
    - Greeting and Small Talk
        - Same script as with Avatar 1
    - Nonverbal Acknowledgers
        - Same script as with Avatar 1
        - Avatar Script – “It’s hard to pass up those sweet treats you may see in the grocery stores around Easter, especially Peeps. (pause) Peeps are usually seen as a sugar coated marshmallow treat in the shape of a yellow chick. (pause) Recently, Peeps have expanded to other holidays like Christmas in which you can find the treat in the shape of a Christmas tree. (pause) Peeps can be eaten just as they are, but some people like them to include them in dessert recipes. (pause) Peeps are a sure way to sweeten any season or holiday, no matter the time of year.” (pause)
    - Topic Maintenance of Non-Preferred Topic

        - Taking Turns by Asking Questions and Making Comments
            - Same script as with Avatar 1
            - Avatar Script – "Today's teens are crazy for popstar Ed Sheeran. (pause) Sheeran was born and raised in the United Kingdom but has fans all over the world. (pause) His most popular songs are 'Bad Habits' and 'Shivers,' both released in 2021. (pause) Recently, he has collaborated with other popular artists including Taylor Swift and Camila Cabello. (pause) Ed Sheeran's success in the music industry is certainly undeniable." (pause)
        - Eye Gaze
            - Same script as with Avatar 1
            - Avatar Script – "My friends and I love to enjoy a good snow day. (pause) Our favorite part about a snow day is that we don't have to go to school! (pause) We also can play outside, build snowmen, or have a snowball fight. (pause) The best thing of all is that there is a big hill beside of my house, so we can go sledding too. (pause) When we get too cold, we come inside to warm up by the fireplace and drink a cup of hot chocolate." (pause)
    - Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
        - Same script as with Avatar 1
        - Conversation topic – "Tell me about your family and what they like to do."
- Avatar 10
    - Greeting and Small Talk
        - Same script as with Avatar 1
    - Nonverbal Acknowledgers
        - Same script as with Avatar 1
        - Avatar Script – "The best teacher I ever had in elementary school was Ms. Johnson. (pause) She taught 5th grade science, and I learned a lot in her class. (pause) My favorite assignment she gave us was to make a model of plant and animal cells using food. (pause) Ms. Johnson also started the 'Going Green' club that encouraged students to recycle their waste. (pause) I hope everyone encounters a teacher that was as great as Ms. Johnson!" (pause)
    - Topic Maintenance of Non-Preferred Topic
        - Taking Turns by Asking Questions and Making Comments
            - Same script as with Avatar 1
            - Avatar Script – "Every summer, my family takes a vacation to Pigeon Forge, Tennessee. (pause) We spend most of our time at an amusement park called Dollywood. (pause) The park gets its name from country music singer Dolly Parton who has part-ownership. (pause) My siblings and I are huge thrill-seekers, so we make it a mission to ride every roller coaster in the park. (pause) My parents don't like rollercoasters as much, so they tend to look in the shops

and watch the shows with performances by musicians and actors." (pause)

- Eye Gaze
  - Same script as with Avatar 1
  - Avatar Script – "During my free time, I like to take time to relax and read books. (pause) The most recent series I have read is the 'The Magic Treehouse.' (pause) The main characters, Jack and Annie, find a magic treehouse full of books. (pause) When the read the books, it takes them to the actual setting of the story. (pause) When they travel to the different places, they learn about the history and people the specific location." (pause)

- Recognizing Cues to 'Wrap Up,' 'Wrap Up,' and Farewells
  - Same script as with Avatar 1
  - Conversation topic – "Talk about the best present you ever received."

"Congratulations! Let's count your coins. Now you can use your coins to play ring toss, balloon pop, or milk bottle toss! For every coin you've earned, you get that many turns at the game. You can use your coins at multiple games if you'd like."

"Are you ready to teleport to the next world so you can complete the final missions?"

Maximum coins that can be earned: 25

1 coin = 1 turn

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Total**
Greeting	/1	/1	/1	/1	/1	/5
Small talk	/1	/1	/1	/1	/1	/5
Nonverbal acknowledgers with nonpreferred story (Award 1 point if nonverbal acknowledgers were used at least <u>one</u> time.)	/1	/1	/1	/1	/1	/5
Topic maintenance with nonpreferred topic – asking questions and	/1	/1	/1	/1	/1	/5

making comments (Award 1 point if at least four on-topic turns were taken.)						
Topic maintenance with nonpreferred topic – eye gaze (Award 1 point if participant shifted gaze toward conversation partner's face at least one time.)	/1	/1	/1	/1	/1	/5
Recognizing cues to 'wrap up'	/1	/1	/1	/1	/1	/5
'Wrap up'	/1	/1	/1	/1	/1	/5
Farewell	/1	/1	/1	/1	/1	/5

Appendix G

Environment 5 Script/Data Sheet

"Now we are back at the lake. Let's have conversations with the individuals here to demonstrate the skills you have learned. I'd like for you to walk over and have a conversation with the person closest to you. When you're finished, come back to get your coin!"

When the participant returns to the researcher's avatar, they will be awarded one coin. Then they will be asked to approach the next avatar and have a conversation.

"Awesome! I'd like you to have a conversation with another person. When you're finished, come back and get your coin!"

When the participant returns to the researcher's avatar, they will be awarded one coin. Then they will be asked to approach the third and final avatar and have a conversation.

"You're doing great! I'd like you to have another conversation with the last person here."

After the participant has had a conversation with three avatars, they can play a fishing game by using their coins.

"Congratulations! You have completed all your missions. Let's take a look at the leaderboard and see how you did!"

"Woah! Nice job. You earned __ coins. For your last reward, you can pick a trophy. Which do you like best?"

"We hope you have had fun completing missions to practice your conversation skills. Thanks for playing!"

Maximum coins that can be earned: 3

1 coin = bronze trophies
2 coins = silver trophies
3 coins = gold trophies

	Trial 1	Trial 2	Trial 3	Total
Greeting	/1	/1	/1	/3
Small talk	/1	/1	/1	/3
Nonverbal acknowledgers with nonpreferred	/1	/1	/1	/3

story (Award 1 point if nonverbal acknowledgers were used at least one time.)				
Topic maintenance with nonpreferred topic – asking questions and making comments (Award 1 point if at least four on-topic turns were taken.)	/1	/1	/1	/3
Topic maintenance with nonpreferred topic – eye gaze (Award 1 point if participant shifted gaze toward conversation partner's face at least one time.)	/1	/1	/1	/3
Recognizing cues to 'wrap up'	/1	/1	/1	/3
'Wrap up'	/1	/1	/1	/3
Farewell	/1	/1	/1	/3

Appendix H

Post-Intervention Survey about Usability Experiences of VR Simulation

Adapted from Bangor et al. (2009) and Brooke (1996)

Demographic Information:

1. I am a ____ (graduate student, speech-language pathologist, occupational therapist, special education teacher, parent, other – please describe).
2. I have taught conversation skills in the past. (yes/no)
3. If you have provided services to individuals with ASD, how many years of experience do you have?

Use the scale below to answer the following questions.
1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Enjoyment

1. I enjoyed the experience.
2. I enjoyed talking with the avatar.
3. I enjoyed practicing parts of a conversation.
4. I enjoyed earning points.
5. I enjoyed playing the games in each environment.

Interacting in the Virtual Environment

6. It was easy to follow instructions for having a conversation.
7. The avatars seemed like real people.
8. It was easy to have a conversation with the avatars.
9. The experience enhanced my conversation skills.
10. The conversation skills I learned in the virtual world will benefit me in the real world.
11. The system was user-friendly.

Equipment

12. The instructions for using the equipment were clear.
13. The headset was comfortable.
14. I was affected by cybersickness during the simulation.
15. I could wear the headset for 30 minutes or more at a time.
16. I would participate in therapy that used virtual reality headsets if I had the opportunity again.

Open ended questions

1. Describe your overall experience while playing the game today.
2. Do you feel this experience would be beneficial for individuals with ASD who need assistance with conversational skills? Explain.
3. Do you feel that adolescents with ASD will be engaged in the experience as it was shown to you today? Explain.

4. What features of the system do you feel worked well (e.g., anything related to the avatar, graphic, audio, overall nature of environment)?
5. How can the system be improved (e.g., anything related to the avatar, graphic, audio, overall nature of environment)?
6. Do you have any feedback on the instruction of conversation skills?
7. What skills are most appropriate to target with this system (e.g., eye gaze, topic maintenance, recognizing cues to 'wrap up,' etc.)?
8. What other therapy applications would you recommend for this system?
9. Would you be interested in using virtual reality in the future? Explain.