

User specifications for neurodiverse students with Autism Spectrum Disorder (ASD): A preliminary study

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ABSTRACT:

The United Nations Sustainable Development Goals (UNSDG) prioritize 'Quality Education' for global peace and prosperity. The Malaysian government's special education reforms are influenced by the 'Shared Prosperity Vision 2030'. Special needs education emphasizes the necessity of incorporating technology into the learning environment to meet neurodiverse learners' communication, teaching, and learning needs. Teachers serve as a liaison between students, parents, and carers. Technological innovations assist instructors in meeting the educational demands of neurodiverse students at all levels. Early intervention-based teaching and learning is widely seen as beneficial to neurodiverse students, particularly those with autism spectrum disorder (ASD). However, students with ASD's genuine needs, acceptance, and preferences are still not given enough attention by technology, particularly from the paradigm of natural user interface (NUI) technology. Therefore, to bridge the identified gap in academic literature, this study investigates the efficacy of user specification in enhancing multimodal interaction for students with ASD. Recognizing the unique communication challenges faced by ASD students, the study addresses the central problem of optimizing interaction interfaces to cater to their specific needs. Through a preliminary study, the aim is to assess the impact of tailored user specifications on improving the user experience of multimodal interaction tools for ASD students. Employing a mixed-methods approach, this study combines qualitative and quantitative measurements and involves Wizard of Oz (Woz), observation, and interview. Results demonstrate promising enhancements in engagement, emotional impact, and communication among ASD students when utilizing tailored multimodal interfaces. In addition, the study also highlights the need for further exploration and refinement in user specification strategies to accommodate the diverse sensory and cognitive profiles within the ASD population. Future research endeavors will focus on the user experience of customized interaction interfaces and explore advanced methodologies for personalized user specification in multimodal interaction systems for ASD students.

KEYWORDS:

Human Computer Interaction, Natural User Interface, Multimodal, Autism Spectrum Disorder, User Experience

Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder that affects communication, social

interaction, and behaviour. Individuals with ASD often struggle with sensory sensitivities and may have difficulty processing social cues [1], [2], [3], [4], [5]. As a result, it is important to provide support using technologies for individuals with ASD to help them thrive and reach their full potential. This can include creating structured routines, providing visual supports, and offering opportunities for social skills development. It is crucial for these individuals to feel understood and supported for them to succeed. Many individuals with ASD also benefit from therapy to address specific challenges and learn coping strategies. With advance of technology, there are now various apps and devices available that can assist individuals with ASD in improving communication, managing emotions, and developing social skills [6], [7], [8], [9]. These technological tools can be personalized to meet the unique needs of everyone, making it easier for them to navigate daily life and achieve their goals.

Digital therapy has become increasingly popular in recent years, providing a convenient and accessible option for individuals with ASD to receive support and guidance. It allows individuals to connect with therapists remotely, overcoming barriers such as transportation and scheduling conflicts. It also provides a comfortable and familiar environment for those who may struggle with in-person sessions. This can lead to increased access to care and improved outcomes for individuals with ASD. Digital therapy [6], [10], [11] offers a wide range of tools and resources tailored to the unique needs of individuals with ASD, including visual schedules, social stories, and sensory activities. Therapists can also utilize video modelling and virtual reality to help individuals practice social skills and navigate real-life situations in a safe and controlled environment. Additionally, online therapy platforms often offer flexibility in terms of scheduling, allowing individuals to receive support at a time that works best for them. Overall, digital therapy has the potential to transform the way individuals with ASD access and engage in therapy, ultimately improving their quality of life.

With the advancement of multimodal technology, it can significantly improve the treatment of ASD children by offering personalized and convenient therapy, bridging resource gaps, and enhancing their potential. It is crucial to continue research and development to ensure accessibility and effectiveness. This technology can contribute to a more inclusive and supportive society, fostering unity and harmony among individuals. Recognizing and appreciating each person's unique qualities and perspectives fosters growth and empathy. By building a world where everyone feels valued and respected, we can create a more inclusive and peaceful society for all. Autism Spectrum Disorder (ASD) children present significant challenges in various aspects of learning in a school and daily life, including social interactions and communication skills. It is crucial for educators and caregivers to understand these challenges and provide appropriate support to help ASD children thrive. By utilizing technology, such as apps and devices tailored to their needs, individuals with ASD can improve their communication abilities and enhance their social interactions. Virtual reality (VR) technology has shown promise in assisting individuals with ASD by providing immersive and customizable environments for therapy and skill development. However, to effectively design VR interventions tailored to the specific needs of ASD children, it is crucial to gather comprehensive user specifications.

This preliminary study aims to investigate the use of multimodal techniques in refining VR technology for ASD children. By employing a Wizard of Oz approach coupled with direct observation, this research endeavors to elucidate the nuanced requirements and preferences of ASD children regarding VR interactions. In addition, this study also conducts an interview with the experts in the field to gather insights on best practices for incorporating VR with multimodal technology in interventions for ASD children. This comprehensive approach aims to create more effective and personalized strategies to support the communication and social development of children with ASD. Understanding these user specifications is paramount in developing VR environments that are engaging, effective, and conducive to the unique learning and therapeutic needs of individuals with ASD. This paper's structure is intended to give a thorough understanding of the needs of ASD children while recommending technological solutions for autism therapy. The literature review is presented in this paper's Section II. The study's methodology, including specific on data collecting and analysis, is covered in Section III. A thorough analysis of the outcomes and conclusions is provided in Section IV. In Section V, we wrap up the report by highlighting the most important conclusions and ramifications of our research.

1) Literature Review

Virtual Reality (VR) has been a widely used for intervention ASD children to improve social skills, communication, and behaviour. It has shown promising results and continues to be a valuable tool in therapy settings. It has the potential to revolutionize the way therapy is delivered and help individuals with ASD thrive in their daily lives including in a school setting where social interactions and communication skills are crucial for success. As technology continues to advance, incorporating VR into therapy for individuals with ASD may become more accessible and effective in addressing their unique needs. This technology has the power to greatly enhance quality of learning for those with ASD. The possibilities for utilizing this technology in therapy settings are endless. It has the potential to revolutionize the way therapy is delivered and help individuals with ASD thrive in their daily lives. Technology has the potential to revolutionize the way that therapy is administered, making it more accessible and effective for individuals with ASD. Technology can provide innovative ways to target specific skills and behaviors in a personalized and engaging manner. By incorporating technology into therapy sessions, therapists can tailor interventions to meet the unique needs of each individual with ASD. This personalized approach can lead to more meaningful progress and increased independence for clients. Additionally, technology can provide a platform for individuals with ASD to practice and generalize skills in a safe and controlled environment. Overall, the integration of technology in therapy holds immense promise for improving outcomes and quality of life for individuals with ASD.

Children with ASD in Malaysia education may benefit greatly from the integration of VR therapy into their school curriculum. By providing a more interactive and engaging learning experience, VR technology has the potential to improve social skills and communication abilities in children with ASD, ultimately enhancing their overall educational experience. Furthermore, the use of VR therapy in schools can also help in reducing sensory overload and anxiety in children with ASD, leading to better focus and attention during learning activities. Overall, the integration of VR technology in education for children with ASD has the potential to revolutionize traditional teaching methods and improve outcomes for these students [8], [12], [13], [14], [15]. By creating a virtual environment that is tailored to their specific needs, children with ASD can practice social interactions in a safe and controlled setting. This can help them build confidence and transfer these skills to real-life situations. Furthermore, VR technology can provide a more engaging and interactive way of learning that caters to the unique learning styles of children with ASD. This can help to increase their motivation and interest in educational activities, leading to improved academic performance. Additionally, the use of virtual reality can also provide opportunities for children with ASD to practice and develop important life skills, such as problem-solving and decision-making, in a supportive and conducive environment. Overall, the incorporation of VR technology in education for children with ASD holds great promise in enhancing their overall development and success in school.

(a) Multimodal Technology for ASD Children in a school setting

Multimodal technology for ASD children has the potential to revolutionize the field of special education by providing personalized and engaging learning experiences. By catering to different learning styles and preferences, multimodal technology can help educators better meet the diverse needs of children with ASD, ultimately promoting a more inclusive and effective educational environment for all students. Furthermore, the interactive nature of VR technology can help improve social skills and communication abilities in children with ASD, which are often areas of difficulty for them. Additionally, the use of multimodal technology can also facilitate better collaboration between parents, educators, and therapists in creating individualized learning plans for each child with ASD. By utilizing VR technology, educators can create virtual environments that simulate real-life social situations, allowing children with ASD to practice and improve their social interactions in a safe and controlled setting. This can help them develop the necessary skills to navigate social situations in the real world more effectively. Furthermore, the collaboration between parents, educators, and therapists through multimodal technology can ensure that the individualized learning plans are tailored to the specific needs and

strengths of each child with ASD, leading to more personalized and successful interventions. Therefore, the integration of multimodal technology in education holds great promise for enhancing the learning experience and outcomes for children with ASD.

By incorporating interactive and engaging activities into their educational programs, children with ASD can build upon their strengths and work on areas of challenge in a supportive environment. This approach can also help them generalize their skills beyond the classroom setting and into everyday life. Additionally, the use of technology can provide immediate feedback and reinforcement, which is essential for promoting learning and motivation in individuals with ASD. As a result, children with ASD can make significant progress in their communication, social, and academic skills, ultimately improving their overall quality of life. By incorporating social skills training and peer interaction opportunities, children with ASD can also develop important social competencies that are crucial for forming relationships and navigating social situations. Furthermore, providing individualized support and accommodations can help children with ASD thrive academically and reach their full potential. Overall, the combination of targeted interventions, social skills training, and personalized support can greatly benefit children with ASD in all aspects of their lives. With the right resources and strategies in place, children with ASD can overcome challenges and achieve success in school, relationships, and beyond. It is essential for educators, therapists, and parents to work together to create a supportive and inclusive environment that allows children with ASD to flourish and reach their goals. Ultimately, by empowering children with ASD with the tools they need to succeed, we can help them lead fulfilling and meaningful lives.

By fostering a collaborative and holistic approach to intervention, we can ensure that children with ASD receive the individualized support they need to thrive. This includes implementing evidence-based practices, such as Applied Behaviour Analysis (ABA) therapy, speech and language therapy, and occupational therapy, to address specific areas of need. Additionally, creating a positive and inclusive school environment that promotes understanding and acceptance can help children with ASD feel valued and supported. By working together to provide the necessary resources and support, we can help children with ASD reach their full potential and lead happy, fulfilling lives. It is crucial for educators, therapists, and parents to collaborate closely to ensure that each child's unique needs are met. With early intervention and consistent support, children with ASD can make significant progress in their development and overall well-being.

This collaboration can involve implementing individualized education plans, providing sensory accommodations, and offering social skills training. It is important for educators to be trained in evidence-based practices for working with children with ASD and for parents to be actively involved in their child's education and therapy. By working together as a team, we can create a supportive and nurturing environment that allows children with ASD to thrive and succeed. With the right support and resources in place, there is no limit to what these children can achieve. For example, a child with ASD may benefit from having a visual schedule to help them navigate their daily routine, as well as sensory tools like fidget toys or noise-cancelling headphones to help them regulate their sensory input. Additionally, social skills training can teach them how to navigate social interactions and build relationships with their peers, ultimately improving their overall well-being and success in school. By creating a supportive and inclusive environment, children with ASD can feel empowered to reach their full potential. Providing specialized education programs tailored to their individual needs can also greatly enhance their academic success. With the right accommodations and understanding from teachers and peers, children with ASD can excel in school and beyond. It is essential to foster a community that embraces neurodiversity and celebrates the unique strengths and abilities of all individuals.

(b) Virtual reality technology in supporting ASD children

Virtual reality technology supported ASD children in improving communication skill, social skill, and reducing anxiety levels. Virtual reality technology has shown promising results in improving the quality of life for individuals with ASD. There is much research conducted on the effectiveness of virtual reality technology in

helping individuals with ASD, and the consensus is that it has great potential in providing meaningful support and intervention. For example, a study found that using virtual reality technology to simulate social interactions helped children with ASD learn and practice appropriate social skills in a controlled environment. By allowing them to repeatedly practice and receive feedback in a safe and comfortable setting, virtual reality technology can help individuals with ASD build confidence and improve their ability to navigate social situations in the real world. Furthermore, other forms of technology such as mobile applications and wearable devices have also shown promise in assisting individuals with ASD in various aspects of their daily lives. These tools can help with communication, organization, sensory regulation, and even behavior management. This research focuses on interactive technologies developed for ASD therapeutic intervention, introducing a conceptual framework for understanding the full spectrum of technologies involved in the ASD context [1]. The study involved 59 participants with significant experience in interacting with individuals diagnosed with ASD in various real-life settings, including therapists, teachers, and parents of children with ASD. The research findings revealed a broad spectrum of technologies involved in ASD interventions, including applications, devices, and robots. The results bring a new perspective on the interactive technologies used in the therapy and diagnosis of ASD and highlight their important characteristics that can serve as a standard in the development of future technological solutions.

One example of technology that has shown promise in assisting individuals with ASD is the use of virtual reality (VR) therapy. VR therapy allows individuals to practice social interactions, communication skills, and sensory regulation in a safe and controlled environment. This immersive technology can help individuals with ASD learn and generalize skills in a way that is engaging and motivating. Additionally, wearable technology such as smart watches and fitness trackers can help individuals with ASD monitor and regulate their own behaviors and emotions. These tools can provide real-time feedback and prompts to help individuals stay on track with their goals and routines. Overall, the integration of technology into therapy and education programs for individuals with ASD holds great potential for improving outcomes and enhancing quality of life.

2) Methodology

The research will be conducted qualitatively. The methodology used in this study takes a multifaceted approach to acquire user specifications for VR technology geared towards ASD children. First, a Wizard of Oz (Woz) technique was used, in which users will interact with a simulated VR world as researchers adjust the system behind the scenes to replicate genuine interactions. This technique enables the investigation of numerous scenarios and functionality in a controlled yet immersive environment. The Woz experiment involved ten (10) children with ASD, representing a variety of ages 6 year to 12 year and functional levels. Concurrently, direct observation is used to capture the participants' naturalistic behaviours and answers. Five (5) ASD children's interventions and VR technology specialists is also be consulted to validate and appraise the specified user requirements. These specialists, with their clinical and technical backgrounds, will provide insights into the feasibility and possible effectiveness of the proposed VR features. This study's thorough methodology (see figure 1) attempts to reveal the complicated demands and preferences of ASD children regarding VR interactions, laying the framework for the development of more targeted and effective interventions.

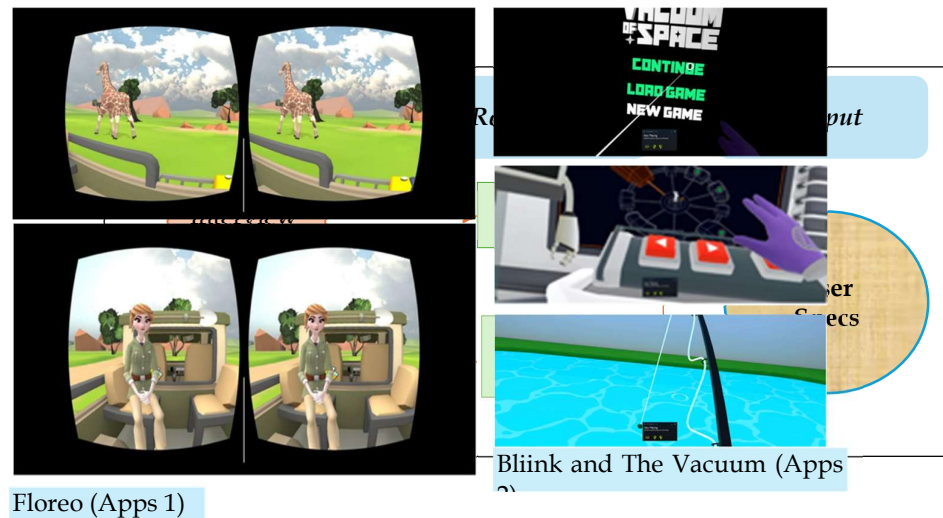


Figure 1 Methodology

Wizard of OZ (Woz) experiment

The Woz experiment was conducted (Figure 2 (a) and figure 2 (a) (i)) to identify the needs of autistic children using VR devices. The experiment was conducted with ten autism children at the Terengganu Autism Association Centre (PAUT), Kuala Terengganu, Malaysia. All the participants are aged 6-12 years. Most of the participants have played VR devices, like to play with VR devices. They use VR devices alone and take an average of two hours a day. An authorization to conduct a Woz experiment involving children as participants at PAUT was given in advance to the centre of PAUT before the experiment conducted.

This study used a checklist form as an instrument for data collection. The form is divided into these parts: difficulty factors, practical guidance, cognitive skills and psychomotor skills, which contains nine items to ensure that the data taken can be analysed properly. The equipment used in the study consisted of a smartphone, a laptop, a projector, a PICO VR headset and a cheap VR headset. Two built-in interactive applications were selected in this study; Floreo and Blink and The Vacuum of Space to identify the type of multimodal signal movement, children's ability to perform multimodal interaction while using digital apps and identifying the importance of multimodal interaction. Respondents need to answer complete set of checklists after play both applications. This process involves a detailed analysis of the VR application. Assessment is carried out individually based on assigned tasks. This test was expected to take about 30 min. The following testing sessions were conducted with a group of children diagnosed with ASD in order to gather insights on their user experience.

Figure 2(a) Application of Floreo and Blink and The Vacuum

i. Procedure of Woz experiment

These are the list of tasks that was assigned to each ASD children during the testing sessions. The following table 1 were the steps that need to be followed by the children.

Blink and The Vacuum (Apps 2)



Figure 2(a)(i) Experiment Woz conducted

Table 1

Steps for ASD Children Doing Task for Both Application (Blink and The Vacuum and Floreo)

Blink and The Vacuum	Floreo
- Using the VR headset to start exploring the Bliink and the application system Vacuum of Space. - Press the trigger button located on the index to set any action. - Select the specified application. - Click “continue” in the application to continue. - System Lobby (Main menu) - Move towards the portal machine. - Put your hands on the red button to use the portal machine. - Choose a map called Atrium Park. - Activity Lobby - Put your hands on the red button pushing in the direction of the jeti. - Click on any available fishing rod according to the same color. - Bring the fishing rod to the jetty for a ride. - Align the fishing rod from the top of the head to the water to catch the fish - Lift the fishing rod as soon as the rope is pulled by the fish. - Put the fishing rod to its place of origin.	- Using the VR headset to start exploring the Floreo application. - Hold interactive objects to make choices. - Look around and follow the instructions of the guide. - Meet the Animals. - Find some different kinds of animals. - See and name the animal. - Watch the animal for at least 3 seconds. - Name the four kinds of animals you see. - Look at it for at least three seconds and name the animal. - Watch It Go. - Find a ziraffe. - Look where he's heading. - Find another animal. - See what the animal's doing. - Repeat until finished. - Replace - Look at Emma the Safari Guide for at least three seconds. - Who Made That Sound? - Listen to the sounds of animals.

10.3	Take the caught fish and put it in the container available.	
10.4	Repeat until the target is reached.	

Observation at Pusat Autisma Terengganu (PAUT)

Observation activities are continuously running in PAUT to obtain user requirements from ASD children. Before an observation is carried out, a study is conducted on the aspect of usability, suitability and skills aspects to ensure that items can be measured during observation. Based on the observation carried out, the study found that there were 65% positive responses to the Bliink and The Vacuum of Space application, 76% positive response to the Floreo application, and also 86% responds positively to the usability aspect. All these items were tested in observations conducted with ten ASD children using the Floreo and VR apps Bliink and The Vacuum. In this study, the checklist form was used as an instrument.

i.Procedure of an observation

The study procedure begins with researchers meeting participants on basic questions about the use of digital devices at home. Next, children need to use the PICO device to play The Bliink and The Vacuum and the VR head set tool to play Floreo as in a figure 2 (b)(i) and figure 3.



Figure 2(b)(i) ASD children play Floreo application

3) Interview the experts

Respondents should answer the interview questions based on their experience with ASD children. This experiment was scheduled around 15-30 minutes. The goal of this expert interview experiment is to gather real-world demands, ideas, and opinions as input in designing a model. The evaluation results are used to determine the real issues faced by children with ASD. The questions are divided into four sections: the respondent's background in the VR application, the ability of children to interact with the Bliink VR app and the Vacuum of Space, multimodal interaction based on eye movement, children's interaction capabilities with the Floero VR app, speech-based interaction, and usability questions. The expert checklist questions are also separated into three areas that address the usefulness, utility, and daily use of technology by children with autism. The checklist sections also include subjective questions for professionals to obtain relevant views and advise based on their expertise dealing with autistic children for stronger data.



Figure 3 ASD children play The Bliink and The Vacuum

i. Procedure of interview

The researcher begins the experiment by introducing himself and explains why the interview is being done. The interview process continued, with the researcher asking questions based on the instrument checklist questions provided. The data from the interview session was analyzed. Finally, the researcher translates, identifies the relationship, and formulates the findings.

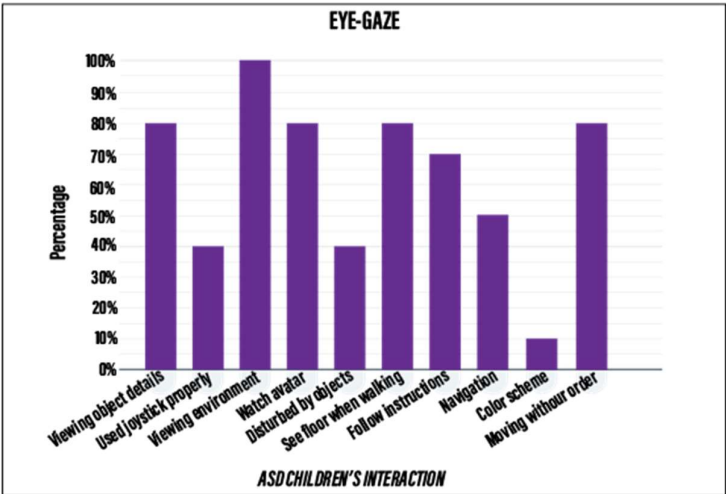
4) Results

This section presents the findings from the evaluation of each method employed, namely Woz, observations, and interviews. This evaluation produced a list of specifications for ASD children's needs, which will be utilised as input to construct a model.

(a) Analysis of Woz experiment

Woz's experimental research revealed that majority of ASD children (100%) are extremely sensitive to virtual settings, allowing them to observe the virtual environment with focused eye-gaze. As many as 80% of ASD children can walkthrough from point A to point B without being directed; 80% of them glance down while walking

or wandering in a virtual environment; and up to 80% of ASD children perceive items in depth. Furthermore, up to 70% of them are capable of following directions. Nonetheless, these ASD children struggle to manipulate the interactive buttons in virtual reality environment (50%). In addition, they are less proficient at using the joystick



correctly and competing with less relevant items or props in a 40%, respectively. Approximately 10% of these children are unhappy with the colour scheme chosen in this VR environment. Figure 4 depicts a percentage bar chart showing ASD children's capacity to communicate through eye-gaze interaction.

Figure 4 ASD children's capacity through eye-gaze interaction

Children with ASD are particularly drawn to voice interaction. They will communicate by naming the creatures they see and will answer to the guides at 90 percent accuracy. They name the animals (80%), speak when they encounter Emma's avatars (80%), mimic the noises of the animals after seeing them (80%), and describe the animals' movements in a virtual world (80%). Approximately 60% of ASD children will scream if they see an animal, and 50% will ask questions after completing the assignment. Figure 5 depicts a bar chart of ASD children's percentage capacity to interact via voice interaction.

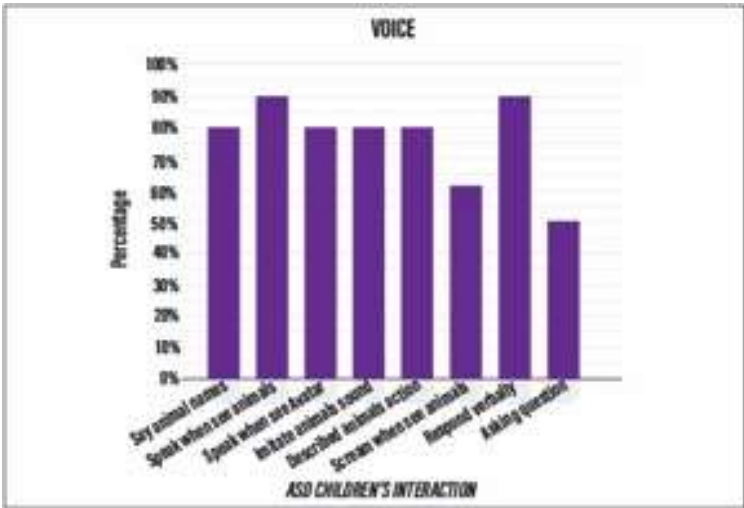


Figure 5 ASD children's capacity through voice interaction

(b) Analysis of observation

Table 2 displays respondents' capacity to interact via eye-gaze and voice with Floreo (Apps 1) and Blink & The Vacuum VR applications (Apps 2). Respondents can easily complete work using the Apps 1 app (80%), while

they struggle with tasks when using Apps 2. Respondents can know that the signal movement has been finished using Apps 1 based on immediate response (80%), however only 7% of respondents know the signal motion has been completed via Apps 2. Respondents are unable to accomplish xxx tasks, meaning that no one can do so using Apps 1, while only 30% can do so using Apps 2. 20% of respondents have difficulty controlling multimodal interactions, resulting in involuntary interaction responses through Apps 1 and only 5% through Apps 2.

Table 2

Observation of Apps 1 and Apps 2

No	Description	FLOREO (Apps 1)	VR BLINK & THE VACUUM (Apps 2)
1	Respondents use the VR app to their own convenience.	100 %	100 %
2	Respondents do the task easily.	80 %	8 %
3	Respondents can perform tasks based on specific, clear and minimal multimodal instructions.	90 %	80 %
4	Respondents know the signal movement is done based on the provision of immediate feedback.	80 %	7 %
5	Respondents could not perform task.	0 %	30 %
6	Respondents struggled to control multimodal interactions, resulting in an unintended interaction response.	20 %	5 %
7	Respondents were unable to touch and take objects with accuracy, or to aim objects.	0 %	75 %
8	Respondents focus only in one direction when doing the task.	80 %	60 %
9	The respondents executed their jobs well.	100 %	10 %
	Average of a Percentage	61%	42%

(c) Analysis of Interview

ASD children aged 6 to 10 frequently utilize digital apps such as YouTube, TV advertising, Tik Tok, games, and apps to gather information and leisure time. Following a learning session, they should be awarded for their good behavior. The use of digital applications can aid in their cognitive and psychomotor development and can be incorporated during intervention sessions. It is also can be used as a module to excite the sensory systems of children with ASD. When wearing a VR assistive device, patients can move their heads. Children can employ fingertips to control digital applications. They are also capable of tapping and scrolling the screen with fingertips, as well as dragging fingers onto the screen. Next, the act of shaking the body in response to anything moving. The application allows users to hear and reshape voices. ASD children are watching videos and alternating eye contact between the screen and the therapist. They can choose the videos that interest them and imitating the movement of everyday life activities through video modelling. In addition, they are viewing or tapping a digital application screen and observing the direction of auditory or visual motion. To move, they touch the screen or perform a job with eye-hand synchronization. Executes touch movements was applied to the application. Children also imitating actions or movements while listening to words or directions. Table 3 present an analysis of interview with experts.

Table 3

Interview with experts

ITEMS	EXPLANATION	PERCENTAGE
Applications used for learning and leisure activities	- ASD children use digital applications for learning and leisure activities. - The use of digital applications for study and leisure activities is authorised with parental and teacher consent.	R1- R5 = 5 Respondent $5/5 * 100 = 100\%$
Need for multidirectional eye-gaze and speech interactions.	- Digital applications widely used by children with ASD. - Interacting with digital apps through eye-gaze movement - Using voice to connect with digital applications.	R1, R3 -R5 = 4 Respondent $4/5 * 100 = 80\%$
Difficulty performing signal movements.	- Children with ASD have difficulties completing signal movements. - The type of signal movement that is difficult to perform. - Difficulty in performing continuous signal movement. - The significance of VR multimodal digital devices for learning and leisure activities	R1, R3, R5 = 3 Respondent $3/5 * 100 = 60\%$

5) Conclusion

In conclusion, the study emphasizes the critical role of user specification in enhancing multimodal interaction interfaces tailored for neurodiverse students with Autism Spectrum Disorder (ASD). By adopting a mixed-methods approach, including Wizard of Oz (WoZ) techniques, observations, and interviews, the research highlights significant improvements in engagement, emotional impact, and communication for ASD students utilizing these customized tools. Despite these promising results, the study emphasizes the necessity for ongoing exploration and refinement of user specification strategies to address the diverse sensory and cognitive needs within the ASD population. Future research will delve deeper into the user experience of bespoke interaction interfaces and aim to develop advanced methodologies for personalized user specification in multimodal interaction systems, thus contributing to the broader goal of inclusive and effective special needs education.

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