Autistic Children's Emotional Engagement in a Virtual Flight Environment

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Abstract- This study explores how virtual reality (VR) can help children with autism better manage the emotional challenges of air travel. Five children on the autism spectrum participated in an immersive VR flight simulation designed to mimic the real experience of flying. Emotional responses were observed before, during, and after the session, and insights were gathered through detailed interviews and structured observations involving both the children and their families. The results highlight VR's potential as a powerful tool for experiential learning, helping children feel more at ease and emotionally prepared for travel-related stress. While the simulation offered a realistic aviation experience, the findings point to a need for more varied and complex scenarios to fully prepare children for the unpredictability of real-life events. Overall, this research supports the growing role of VR as a supportive technology for autistic children, helping them build emotional readiness and confidence in facing real-world situations like flying.

Keywords- Autism Spectrum Disorder; Virtual Reality; Assistive Technology.

1. Introduction

Autism spectrum disorder (ASD) is a developmental disability characterized by persistent impairments in social communication and interactions, and restricted, repetitive patterns of behavior, interests, or activities **[1]**. Individuals with ASD often face challenges in eye contact, understanding emotions, and forming relationships, alongside repetitive behaviors, strict routines, and unusual sensory responses **[2], [3], [4]**. Symptoms typically emerge in early childhood and vary in severity **[1], [4], [5]**. ASD has a strong genetic basis, with high family recurrence rates and differences in brain development implicated; environmental factors may also contribute, though to a lesser extent **[1], [3]**. Diagnosis relies on behavioral assessments, as there are no definitive medical tests **[1], [6]**. It affects around 1% of the population, with higher rates in males and frequent comorbidities like anxiety or intellectual disability **[5], [6]**. While early intervention improves outcomes, most individuals require lifelong support **[2], [6]**.

Recent literature on autism and travel reveals a growing but still limited understanding of the unique challenges faced by autistic individuals and their families when engaging in tourism and transportation. New environments, particularly travel settings, present significant challenges for children with ASD due to heightened sensory sensitivities, a strong preference for routine, and difficulties in coping with unpredictability. Airports are often overwhelming, with bright lights, loud noises, crowded spaces, and unfamiliar social dynamics, which can trigger anxiety, distress, and behavioral difficulties **[7], [8], [9]**. These experiences not only impact the child but also place additional stress on families, often limiting their ability or willingness to travel **[7], [8]**. Studies have highlighted major barriers such as sensory overload, unpredictability, and limited support services during air travel, public transport, and family vacations **[10]**. Families often report heightened stress due to a lack of autism-aware travel services and environments that fail to accommodate sensory and communication needs **[11], [12]**. Although efforts like inclusive airport design and peer-mediated travel training show promise **[13], [14]**, research is still sparse on systematic interventions and industry-wide strategies. A significant gap exists in exploring how different travel modes and destinations could adapt to meet autistic travelers' evolving developmental and sensory needs across the lifespan.

Current research highlights that emotion regulation (ER) is a significant challenge for individuals with autism spectrum disorder (ASD), contributing to social difficulties, behavioral problems, and co-occurring mental health conditions such as anxiety and depression. Children with autism often exhibit emotional dysregulation through meltdowns, aggression, or withdrawal, which can persist into adolescence and adulthood **[15], [16]**. Studies indicate that deficits in both emotional awareness and executive functioning hinder autistic individuals' ability to manage arousal and adapt behaviors in social contexts **[17], [18]**. Importantly, emotion dysregulation is not strongly correlated with IQ, underscoring the need for targeted interventions across cognitive levels **[15]**. Emerging interventions such as the Emotional Awareness and Skills Enhancement (EASE) program have shown promise in improving ER by teaching mindfulness and emotional awareness techniques **[19]**. Despite progress, gaps remain in scalable assessments and in adapting treatments to individual neurobiological profiles, particularly for those with demand-avoidant traits **[20]**. Overall, strengthening emotion regulation skills is critical for enhancing long-term outcomes in individuals with ASD. Children with ASD tend to seek predictability and are more likely to avoid unfamiliar environments that disrupt their established routines **[7], [21]**. In such situations, they may exhibit increased anxiety, repetitive behaviors, or emotional meltdowns **[7], [8], [9], [21]**. These responses reflect the broader difficulties they face in navigating new sensory and social environments **[7], [8], [21]**.

To address these challenges, virtual reality (VR) technology has emerged as a promising intervention tool. VR is increasingly recognized as a promising simulation tool to support children with ASD, particularly in building social, communication, and daily living skills. VR provides immersive, interactive environments where autistic children can safely practice behaviors that might be overwhelming or difficult to simulate in real life, such as air travel, social interactions, or emergency responses **[22]**. Studies show that VR-based interventions have successfully enhanced emotional recognition, task performance, and situational preparedness in autistic children **[23], [24]**. For example, VR tools designed for fire safety or disaster readiness allow autistic users to repeatedly engage in realistic decision-making tasks, improving safety awareness in a non-threatening format **[25], [26]**. Moreover, VR interventions have been shown to improve attention and engagement during learning, especially when combined with gamification or personalized avatars **[27], [28]**. VR simulations, such as airplane or airport environments offer controlled, safe, and repeatable experiences that can help desensitize children to the stressors associated with travel **[29], [30]**. Through repeated exposure and guided interaction, VR can enhance coping skills and promote the transfer of learned behaviors to real-world settings **[29], [30]**. Airports are a focal point for VR-based interventions due to their complex sensory and social demands **[7], [30]**. While cost and accessibility remain barriers to widespread implementation, current literature affirms VR's potential as an innovative and effective tool in autism interventions.

The present study aims to explore how children with ASD emotionally and behaviorally respond to a VR airplane simulator, with a specific focus on the airport environment. By simulating this travel experience, the study seeks to reduce anxiety, improve adaptability, and enhance travel readiness in children with ASD.

2. Methodology

2.1. Study Design

This study sets out to explore how children with ASD emotionally respond to a VR airplane simulation. Approved by the Institutional Review Board (ID#QBRI-IRB-2023-99), the research was designed to create a safe and immersive experience where participants could engage with a simulated flight environment. A qualitative approach was used to gather rich, first-hand insights through semi-structured interviews, structured observations, and brief questionnaires. This flexible methodology enabled researchers to better understand each child's unique experience and identify patterns in how they responded to the VR environment. A pre- and post-test format was applied to measure any changes in emotions, attitudes, or comfort levels before and after the simulation, offering a clear picture of the impact of the experience

2.2. Simulation Experience: Creating a Realistic Travel Setting

To closely mimic the experience of air travel, children were seated in airplane-style chairs facing a screen that played a video of a flight attendant delivering safety instructions and welcoming passengers. To add to the realism, a subwoofer played background airplane sounds, helping to recreate the sensory atmosphere of a real flight. For children sensitive to VR headsets, the simulation was also available in a standard screen format. The entire session lasted between two and five minutes, giving children just enough exposure to become familiar with the travel experience without feeling overwhelmed. Participants could choose whether or not to wear the VR headset, making the setup adaptable to their individual comfort levels. (See Figure 1 for a visual of the setup.)

Figure 1: The Simulation Setting

2.3. The Procedure

Participants for the study were selected using purposive sampling, in collaboration with Mada- Qatar Assistive Technology Center, that invited eligible families. Upon arrival, families were welcomed warmly and provided with a clear explanation of the study, its purpose, duration, confidentiality measures, and their rights as participants. Informed consent was obtained from the parents or guardians, while children provided assent, affirming their willingness to participate. Before the VR experience began, families completed a short interview and questionnaire covering demographic details and prior travel experiences with their child. These interviews were audio-recorded for accuracy with the family's consent.

The study study utilized Go Talk Now, an augmentative and alternative communication (AAC) device that offers voice output when images are tapped to help children express their feelings before the simulation. This tool was specifically recommended by center specialists due to the children's familiarity with it.

Each child, accompanied by a family member, then entered the simulation room for the virtual airplane experience. After exiting, they were asked to share how they felt using the same AAC device. The researcher carefully observed and recorded responses. Finally, a post-experience interview was conducted with families to capture their reflections on the VR simulator and its impact.

3. Result

Feedback gathered from both children and their families during the study was analyzed using an inductive, data-driven thematic analysis approach. This method helped uncover four key themes: emotional responses, experiential learning, realism of the simulation, and suggestions for improving the VR experience.

3.1. Participant Overview

A total of five children diagnosed with ASD took part in the study. To ensure confidentiality, each participant is referred to by a unique code (e.g., N1, N2, etc.). Table 1 provides a summary of participant demographics. Three children (N1, N2, N3) had prior experience with VR games, and all participants, except N2, had traveled by airplane regularly. N2 had only flown once, at nine months old. All five children chose to wear the VR headset during the simulation.

TABLE I. PARTICIPANT DEMGRAPHICS

Participant Number	**Participants Demographics**		
	Age (Years)	**Autism severity**	**Verbal or non–verbal**
N1	8	Low	Verbal
N2	13	Low	Verbal
N3	12	Low	Verbal
N4	16	Moderate	Partially
N5	10	Low	Partially

3.2. Emotional Engagement and Experiential Learning

1. Children’s Reactions

During the VR flight simulation, children with ASD consistently displayed positive emotional responses. Many expressed feelings of happiness, excitement, and enjoyment, indicating that the simulation was not only tolerable but also engaging. Some children expressed interest in repeating the experience, reinforcing the idea that the immersive environment felt playful and enjoyable:

- “*It was like a game and entertained me.*” - Participant N1
- “*I was happy, and I liked the experiment.*” - Participant N2

2. Parent Observations of Child Emotions

Families provided valuable insights into the emotional states of their children throughout the simulation. Several parents reported that their children appeared excited, happy, and eager to participate:

- “*My child was genuinely excited during the experiment.*” -Family of N1
- “*My child seemed happy with the experiment and expressed a desire to participate*

again." Family of N3

3.3. VR as a Tool for Experiential Learning

Another core theme that emerged was the role of VR in promoting experiential learning, a process where children gain knowledge through direct interaction and sensory experience [33]. The VR airplane setting allowed children to explore elements like seats, overhead compartments, and cabin structure, offering a tactile and immersive learning environment. This practical exposure supported the transformation of novel experiences into meaningful understanding.

One parent noted: **"***The experience is very important. He interacted with the environment, exploring chairs and the bag shelf. Simulation is a great tool to gain experience for children." -Famaily of N4*

3.4. Interactive Engagement Through VR

The VR airplane simulation encouraged active exploration and interaction, allowing children with ASD to engage meaningfully with their surroundings. Participants interacted with elements such as seats, seatbelts, and baggage racks, fostering hands-on learning within a controlled environment. This interaction played a vital role in building familiarity and comfort with the travel setting.

- *"He interacted with the environment, exploring chairs and the bag shelf."* -Family of N4
- *"My child kept exploring and interacting with the environment."* - Family of N5

3.5. Supporting Travel Preparation

Families consistently reported that the VR simulation helped their children better understand and anticipate what to expect during real-life air travel. The immersive experience introduced the children to seating layouts, safety instructions, and general airplane etiquette-all of which helped reduce anxiety about unfamiliar experiences.

- *"Simulation is a very important tool to prepare the autistic child for new experiences such as airplane travel."* - Family of N1
- *"Now that he's had this exposure, it might be less annoying or scary."* -Family of N2
- *"This experiment helps by giving exposure to the seats, the environment, and safety instructions."* - Family of N3

3.6. Realism and Near-Authentic Experience

A strong theme that emerged was the high level of realism in the simulation. Both children and parents highlighted how closely the environment mimicked a real airplane cabin. From seating arrangements to seatbelts and windows, the details contributed to a sense of authenticity that enhanced the learning experience.

- *"The room looked exactly like an airplane cabin."* - Families of N4 and N5
- *"Same seat, same seatbelt, same windows, and same bags shelf."* - Participant N1
- *"It looked like a real plane cabin."* - Family of N3

3.7. Safe and Structured Learning Space

The simulation provided a quiet, structured, and sensory-friendly alternative to the typically overwhelming environment of real airplanes. This created a safe space where children could learn and practice essential behaviors without the pressure or unpredictability of actual travel.

"I liked the simulation more than the real plane because the place is quieter and more organized." - Parent of N5

3.8. Recommendations for Enhancing VR Simulations

Feedback from families revealed several practical recommendations aimed at enhancing the effectiveness of the VR flight simulation experience. These suggestions focus on increasing the complexity and realism of the scenarios to better prepare children with ASD for the broader spectrum of real-life travel and milestone experiences.

Parents emphasized the need to include more nuanced and dynamic features in the simulation to replicate actual flight experiences. One parent suggested simulating key travel events such as:

1. **Takeoff and Landing with Sound Effects**:

"A more complex scenario with the plane taking off and landing, sound effects, a flight attendant helping him find his seat, and instructions on using seat belts would be very helpful." - Family of N2

This highlights the importance of familiarizing children with auditory and procedural cues in air travel, which are often sources of anxiety.

2. Simulate Challenging Travel Milestones

Another parent identified high-stress stages of travel, such as boarding, security checks, and waiting in line, as critical areas that should be included in the VR experience.

"The most difficult parts for families are boarding, weighing, and waiting in line. These should be included in the simulation." - Family of N3

Incorporating these transitional and often chaotic moments can help desensitize children to potential stressors and prepare them for real-world challenges.

3. Expand Simulations Beyond Travel

Beyond air travel, families saw the potential of VR as a tool to prepare children for other milestone experiences. Suggestions included:

“Creating more simulation scenarios, like going to the dentist or other important milestones, would be great.” - Family of N1

This insight broadens the application of VR beyond aviation, positioning it as a powerful tool for preparing autistic children for various anxiety-inducing or unfamiliar situations.

4. Discussion

This study demonstrates the significant promise of VR in supporting children diagnosed with autism as they prepare for unfamiliar and often overwhelming experiences, specifically, air travel. Through an immersive flight simulation, children engaged with their environment, expressed positive emotions, and practiced behaviors that are otherwise difficult to rehearse in real life. The results not only affirm VR’s emotional and educational impact but also offer practical insights into how such interventions can be designed and scaled in broader therapeutic or educational contexts.

One of the most encouraging outcomes was the consistently positive emotional response observed in the children. They showed signs of curiosity, joy, and comfort while interacting with the simulated environment. This emotional resonance aligns with [31], who highlight the role of “presence” in VR as a driver of emotional involvement and learning. The immersive nature of the flight simulation appeared to enable a state of “flow,” a psychological condition described by Csikszentmihalyi [32], in which individuals become deeply engaged in an activity that matches their abilities with an appropriate level of challenge. Such experiences not only make learning enjoyable but can also regulate anxiety and build emotional resilience.

Comparable findings in other neurodevelopmental populations, such as children with cerebral palsy, reinforce this outcome. Reid’s research demonstrated that VR can significantly increase playfulness and concentration through flow states, echoing our participants’ reactions [33]. In this study, the ability to interact safely and autonomously within the virtual environment allowed children with autism to build confidence and explore without the pressures typically associated with public or sensory-intensive settings.

In addition to emotional benefits, the VR flight simulation proved effective as a platform for experiential learning. Rooted in Kolb’s learning theory, this approach emphasizes knowledge acquisition through direct experience [34], [35]. Within the VR setting, children actively practiced boarding behaviors, engaged with physical elements such as seatbelts and tray tables, and responded to structured cues within the cabin. This supports earlier findings by Kandalaft et al. [36], who demonstrated that VR-based training can enhance social and functional skills in individuals with autism. The strength of VR lies in its ability to offer a safe, repeatable, and controlled learning environment. Children can rehearse scenarios multiple times, receive feedback, and gradually build competence in settings that might otherwise be inaccessible. Furthermore, VR simulations allow for customization, making them adaptable to varying developmental needs and sensory profiles.

A defining feature of the flight simulation's success was its attention to realism. Participants and their families repeatedly noted how the environment mirrored a real aircraft cabin, complete with seats, seatbelts, windows, and baggage compartments. This level of fidelity is crucial, as research shows that skill generalization improves when simulated environments closely match real-world conditions [37], [38]. Moreover, the calm and structured nature of the VR environment offered a stark contrast to the chaotic and sensory-heavy experience of actual airports or flights. For children with autism, who are often highly sensitive to unpredictability, this made the simulation not only more accessible but also more effective in fostering familiarity without overwhelming them.

The findings of this study have meaningful implications for the use of VR technology beyond just air travel. By allowing children to familiarize themselves with new experiences in a low-stress, highly controlled environment, VR interventions can reduce anxiety, improve preparedness, and enhance overall quality of life for both children and their families. Simulations can be further extended to other real-world challenges -visiting the dentist, attending social events, or navigating public transport, making VR a versatile tool for daily life preparation. Additionally, the results suggest that emotional readiness, experiential learning, and environmental realism are not isolated components, but work together synergistically. This opens the door to multidisciplinary VR applications, combining behavioral therapy, occupational therapy, and special education practices into one integrated platform.

Despite its promising results, the study does carry some limitations. The small sample size restricts the generalizability of findings, and the reliance on parent-reported outcomes introduces the potential for subjective bias. Objective physiological data, such as heart rate or stress biomarkers, could provide more robust evidence of emotional impact in future studies. Moreover, while the immediate effects were positive, the study did not assess long-term outcomes or real-world transfer of skills post-simulation. It remains unclear how enduring the benefits are, or whether they hold up under the actual pressures of air travel. Future research should address these gaps through longitudinal designs and control comparisons.

Building on this initial success, future VR interventions should explore more complex and realistic scenarios, such as takeoff, landing, queuing, or interaction with flight crew, to better simulate the full travel experience. Expanding the use of VR into other domains of life (e.g., medical appointments, school transitions, or social gatherings) could offer even broader benefits. There is also potential in enhancing VR systems with adaptive sensory elements like soundscapes, tactile feedback, and real-time emotional tracking using AI or biometric sensors. These enhancements could not only deepen immersion but also provide practitioners with live feedback on how children are reacting during the simulation. Such data would be invaluable for tailoring interventions and supporting more personalized therapeutic strategies.

5. Conclusion

This study highlights the promising potential of VR as an educational and preparatory tool for children with ASD, specifically through the novel use of a VR flight simulator. By immersing participants in a realistic travel environment, the research offered valuable insights into their emotional and behavioral responses. Four key themes emerged: emotional engagement, experiential learning, the realism of the simulation, and constructive feedback for future improvement. The study revealed that VR can evoke positive emotional reactions and provide a safe, enjoyable space for children with ASD to learn and explore. These findings support the idea that immersive experiences, such as VR flight simulations, can foster deep engagement, consistent with the principles of flow theory and enhance the learning process. Additionally, the active involvement of children during the simulation reflects the principles of Kolb's experiential learning model [34], emphasizing VR's effectiveness in creating hands-on, meaningful learning opportunities. This research makes a compelling case for integrating VR into educational strategies designed for children with ASD. Importantly, participants' suggestions to include more complex and varied scenarios point toward future directions for improving VR applications, potentially increasing the real-world applicability and generalization of skills learned in virtual environments.

References

[1] P. Joon, A. Kumar, and M. Parle, 'What is autism?', *Pharmacol. Rep.*, vol. 73, pp. 1255–1264, 2021, doi: 10.1007/s43440-021-00244-0.
[2] R. Barnett, 'Autism', *The Lancet*, vol. 387, 2016, doi: 10.1016/S0140-6736(16)30530-X.
[3] C. Lord, M. Elsabbagh, G. Baird, and J. Veenstra-VanderWeele, 'Autism spectrum disorder', *The Lancet*, vol. 392, pp. 508–520, 2018, doi: 10.1016/S0140-6736(18)31129-2.
[4] J. McPartland and K. Law, 'Autism Spectrum Disorder.', *Am. Fam. Physician*, vol. 94 12, p. Online, 2019, doi: 10.1016/B978-0-12-397045-9.00230-5.
[5] M. Nadeem *et al.*, 'Autism - A Comprehensive Array of Prominent Signs and Symptoms.', *Curr. Pharm. Des.*, 2021, doi: 10.2174/1381612827666210120095829.
[6] C. Lord *et al.*, 'Autism spectrum disorder', *Nat. Rev. Dis. Primer*, vol. 6, pp. 1–23, 2020, doi: 10.1038/s41572-019-0138-4.
[7] M. H. Black *et al.*, 'Considerations of the built environment for autistic individuals: A review of the literature', *Autism*, vol. 26, pp. 1904–1915, 2022, doi: 10.1177/13623613221102753.
[8] R. A. Qutub, Z. Luo, C. Vasilikou, T. Tavassoli, E. Essah, and H. Marcham, 'Impacts of school environment quality on autistic pupil's behaviours – A systematic review', *Build. Environ.*, 2024, doi: 10.1016/j.buildenv.2024.111981.
[9] G. Williams, J. Corbyn, and A. Hart, 'Improving the Sensory Environments of Mental Health in-patient Facilities for Autistic Children and Young People', *Child Care Pract.*, vol. 29, pp. 35–53, 2023, doi: 10.1080/13575279.2022.2126437.
[10] R. Dempsey, O. Healy, E. Lundy, J. Banks, and M. Lawler, 'Air travel experiences of autistic children/young people', vol. 2, p. 100026, 2021, doi: 10.1016/J.ANNALE.2021.100026.
[11] Z. Zhao, D. Shi, X. Qi, Y. Shan, and X. Liu, 'Family travel among people with autism: challenges and support needs', *Int. J. Contemp. Hosp. Manag.*, 2023, doi: 10.1108/ijchm-10-2022-1229.
[12] D. Sedgley, A. Pritchard, N. Morgan, and P. Hanna, 'Tourism and autism: Journeys of mixed emotions', *Ann. Tour. Res.*, vol. 66, pp. 14–25, 2017, doi: 10.1016/J.ANNALS.2017.05.009.
[13] M. C. Chiscano, 'Autism Spectrum Disorder (ASD) and the Family Inclusive Airport Design Experience', *Int. J. Environ. Res. Public. Health*, vol. 18, 2021, doi: 10.3390/ijerph18137206.
[14] B. Pfeiffer, A. P. Davidson, E. Brusilovskiy, C. Feeley, M. Kinnealey, and M. Salzer, 'Effectiveness of a peer-mediated travel training intervention for adults with autism spectrum disorders', *J. Transp. Health*, 2024, doi: 10.1016/j.jth.2024.101781.
[15] L. D. Berkovits, A. Eisenhower, and J. Blacher, 'Emotion Regulation in Young Children with Autism Spectrum Disorders', *J. Autism Dev. Disord.*, vol. 47, pp. 68–79, 2016, doi: 10.1007/s10803-016-2922-2.
[16] D. Zecevic, 'EMOTION REGULATION IN AUTISM SPECTRUM DISORDER: EFFECTS ON ANXIETY AND DEPRESSION- A SCOPING REVIEW', *Multidiscip. Pristupi U Edukac. Rehabil.*, 2023, doi: 10.59519/mper5205.

[17] C. M. Conner, A. T. Wieckowski, T. N. Day, and C. Mazefsky, 'Emotion Development in Autism', *Oxf. Handb. Emot. Dev.*, 2022, doi: 10.1093/oxfordhb/9780198855903.013.11.

[18] J. M. Lim, 'Emotion regulation and intervention in adults with autism spectrum disorder: a synthesis of the literature', *Adv. Autism*, 2019, doi: 10.1108/aia-12-2018-0050.

[19] C. M. Conner, S. White, K. B. Beck, J. Golt, I. C. Smith, and C. Mazefsky, 'Improving emotion regulation ability in autism: The Emotional Awareness and Skills Enhancement (EASE) program', *Autism*, vol. 23, pp. 1273–1287, 2018, doi: 10.1177/1362361318810709.

[20] N. Greaves, 'Emotion regulation difficulties and differences in autism including demand-avoidant presentations—A clinical review of research and models, and a proposed conceptual formulation: Neural-preferencing locus of control (NP-LOC)', *JCPP Adv.*, 2024, doi: 10.1002/jcv2.12270.

[21] J. Nešić, 'Attuning the world: Ambient smart environments for autistic persons', *Phenomenol. Cogn. Sci.*, 2024, doi: 10.1007/s11097-024-10021-y.

[22] M. Zhang, H. Ding, M. Naumceska, and Y. Zhang, 'Virtual Reality Technology as an Educational and Intervention Tool for Children with Autism Spectrum Disorder: Current Perspectives and Future Directions', *Behav. Sci.*, vol. 12, 2022, doi: 10.3390/bs12050138.

[23] N.-C. Kuo and Y. Wang, '[Recent advances in the virtual reality technology for treating children with autism spectrum disorder].', *Zhongguo Dang Dai Er Ke Za Zhi Chin. J. Contemp. Pediatr.*, vol. 26 4, pp. 414–419, 2024, doi: 10.7499/j.issn.1008-8830.2310142.

[24] A. Al-Saddi, D. Al-Thani, and A. Othman, 'Identifying Emotions of Children with Autism During a Virtual Reality Simulation of an Airplane', *2023 10th Int. Conf. Behav. Soc. Comput. BESC*, pp. 1–8, 2023, doi: 10.1109/BESC59560.2023.10386659.

[25] T. NithyaShree and A. Selvarani, 'Virtual Reality based System for Training and Monitoring Fire Safety Awareness for Children with Autism Spectrum Disorder', 2020, doi: 10.1109/ICDCS48716.2020.243541.

[26] R. Fino, M. J. Lin, A. R. Caballero, and F. F. Balahadia, 'Disaster Awareness Simulation for Children with Autism Spectrum Disorder Using Android Virtual Reality', *J. Telecommun. Electron. Comput. Eng.*, vol. 9, pp. 59–62, 2017.

[27] S. Vidhusha, B. Divya, K. Anandan, R. Narayanan, and D. Yaamini, 'Cognitive Attention in Autism using Virtual Reality Learning Tool', *2019 IEEE 18th Int. Conf. Cogn. Inform. Cogn. Comput. ICCICC*, pp. 159–165, 2019, doi: 10.1109/ICCICC46617.2019.9146086.

[28] C. R. Ramachandiran, N. Jomhari, S. Thiyagaraja, and M. Maria, 'Virtual Reality Based Behavioural Learning for Autistic Children.', *Electron. J. E-Learn.*, vol. 13, pp. 357–365, 2015.

[29] Í. A. P. de Moraes *et al.*, 'Motor learning and transfer between real and virtual environments in young people with autism spectrum disorder: A prospective randomized cross over controlled trial', *Autism Res.*, vol. 13, 2020, doi: 10.1002/aur.2208.

[30] E. Sokolowska, B. Sokołowska, S. J. Chrapusta, and D. Sulejczak, 'Virtual environments as a novel and promising approach in (neuro)diagnosis and (neuro)therapy: a perspective on the example of autism spectrum disorder', *Front. Neurosci.*, vol. 18, 2025, doi: 10.3389/fnins.2024.1461142.

[31] T. A. Mikropoulos and A. Natsis, 'Educational virtual environments: A ten-year review of empirical research (1999–2009)', *Comput. Educ.*, vol. 56, no. 3, pp. 769–780, Apr. 2011, doi: 10.1016/j.compedu.2010.10.020.

[32] J. Nakamura and M. Csikszentmihalyi, 'Flow Theory and Research', in *The Oxford Handbook of Positive Psychology*, S. J. Lopez and C. R. Snyder, Eds., Oxford University Press, 2009, p. 0. doi: 10.1093/oxfordhb/9780195187243.013.0018.

[33] D. Reid, 'The influence of virtual reality on playfulness in children with cerebral palsy: a pilot study', *Occup. Ther. Int.*, vol. 11, no. 3, pp. 131–144, 2004, doi: 10.1002/oti.202.

[34] P. Lindner *et al.*, 'Creating state of the art, next-generation Virtual Reality exposure therapies for anxiety disorders using consumer hardware platforms: design considerations and future directions', *Cogn. Behav. Ther.*, vol. 46, no. 5, pp. 404–420, Sep. 2017, doi: 10.1080/16506073.2017.1280843.

[35] A. Y. Kolb and D. A. Kolb, 'Experiential Learning Theory', in *Encyclopedia of the Sciences of Learning*, Springer, Boston, MA, 2012, pp. 1215–1219. doi: 10.1007/978-1-4419-1428-6_227.

[36] M. R. Kandalaft, N. Didehbani, D. C. Krawczyk, T. T. Allen, and S. B. Chapman, 'Virtual Reality Social Cognition Training for Young Adults with High-Functioning Autism', *J. Autism Dev. Disord.*, vol. 43, no. 1, pp. 34–44, Jan. 2013, doi: 10.1007/s10803-012-1544-6.

[37] Naomi Josman, Hadass Milika Ben-Chaim, Shula Friedrich, and Patrice L Weiss, 'Effectiveness of virtual reality for teaching street-crossing skills to children and adolescents with autism', *Int. J. Disabil. Hum. Dev.*, vol. 7, no. 1, pp. 49–56, Jan. 2008, doi: 10.1515/IJDHD.2008.7.1.49.

[38] J. Parong and R. E. Mayer, 'Learning science in immersive virtual reality', *J. Educ. Psychol.*, vol. 110, no. 6, pp. 785–797, 2018, doi: 10.1037/edu0000241.

