

Adapt applied behavior analysis methods for autism spectrum disorder children in earthquake using 3D simulation

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ABSTRACT

This paper aims to improve disaster preparedness in children with autism spectrum disorder (ASD) by employing immersive 3D simulations designed to enhance self-protection skills. Children with ASD often face difficulties in social interaction and interpreting complex instructions, posing challenges to acquiring essential disaster-response skills. Our approach combines applied behavior analysis with virtual simulations, creating a structured and accessible learning model tailored to the cognitive needs of children with ASD. Utilizing Unity3D, the 3D earthquake simulations provide a realistic environment featuring responsive graphics and sound, which engage children in lifelike scenarios, fostering better learning outcomes. The study's experimental design demonstrated that these simulations significantly enhance situational readiness among ASD children, as observed in improved behavioral responses during trials. Results suggest the model's potential as an effective educational tool in special education settings, advocating for its integration into school curricula to support ASD children in acquiring essential safety skills. The findings highlight the promise of virtual simulations in special education, suggesting further research on their application in diverse emergency preparedness contexts.

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1. INTRODUCTION

Autism spectrum disorder (ASD) is a developmental condition marked by repetitive behaviors, restricted interests, and social challenges [1]. ASD's prevalence is rising, with nearly 2% of children in the U.S. identified with the disorder according to the Centers for Disease Control and Prevention's Autism and Developmental Disabilities Monitoring (ADDM) Network [2]. However, safety skills training, particularly for natural disasters like earthquakes, remains underemphasized for individuals with ASD, despite their increased vulnerability to injury or mortality in such scenarios [3], [4]. Lacking essential safety skills can elevate the risk of harm for these individuals, underscoring the need for preparedness education. Earthquakes, which caused over 747,234 deaths globally from 1998 to 2017 (55% of all natural disaster-related deaths), exemplify the importance of such training [5]. Figure 1 illustrates the proportion of fatalities across various natural disaster categories.

Recent research on ASD highlights the effectiveness of combining applied behavior analysis (ABA) methods with virtual reality (VR) technologies. Bergstrom *et al.* [6] demonstrated that ABA techniques like role-playing and prompting effectively taught children with ASD to seek assistance when lost in public. Kum and Bilmez [7] showed that virtual learning environments improved empathy comprehension, enhancing

participants' social performance. Silva *et al.* [8] highlighted the adaptability of ABA, reporting significant skill improvement in children with ASD after 12 months of therapy. A meta-analysis by Eckes *et al.* [9] confirmed ABA's effectiveness in enhancing cognitive and adaptive behaviors, while Dixon *et al.* [10] demonstrated VR's utility in teaching pedestrian safety. Studies by Dan *et al.* [11] and Sait *et al.* [12] further emphasized VR's potential to improve social skills, reduce resources, and support real-world generalization.

This potential is illustrated in Figure 2 [12], showcasing the AutiVE system's immersive VR environment for simulating real-life social interactions and emergencies. These findings underscore the promise of integrating ABA with VR to improve learning and safety outcomes for children with ASD. While simulator technology and ABA show promise for supporting autistic individuals, existing studies face limitations such as outdated content, small sample sizes, and challenges in virtual interaction. The integration of ABA and immersive VR remains underexplored. To address this, we propose a VR-based application combining ABA with discrete trial training or DTT to teach earthquake preparedness to children with ASD. DTT, a structured technique emphasizing personalization and repetition, is adapted to meet the unique challenges autistic children face during emergencies, aiming to enhance adaptive skills and safety [13], [14].

The subsequent sections outline our methodology, including a step-by-step description of the solution and data collection methods. Results and discussion will focus on the development and impact of the VR earthquake simulation, highlighting its effectiveness in improving preparedness for ASD children. development of a VR earthquake simulation application using the ABA approach, emphasizing its significance and effectiveness in addressing the safety needs of ASD children during natural disasters.

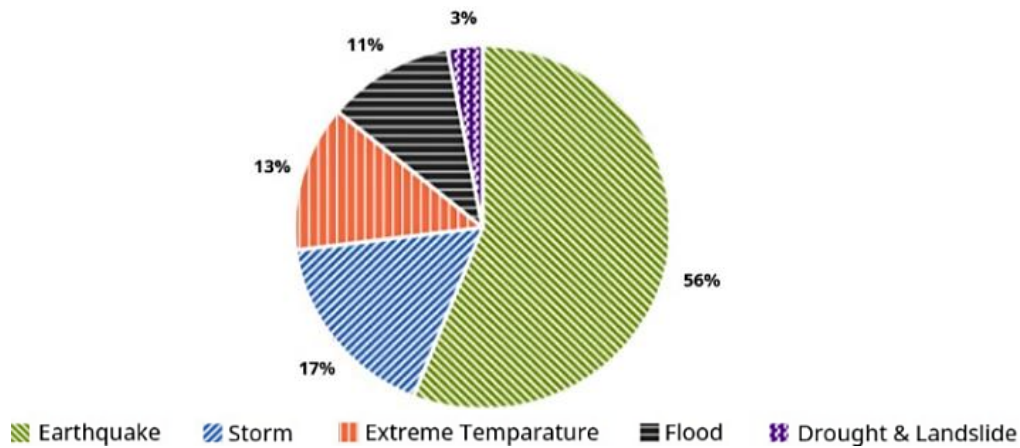


Figure 1. Percentage of deaths per disaster type from 1998 to 2017 [5]

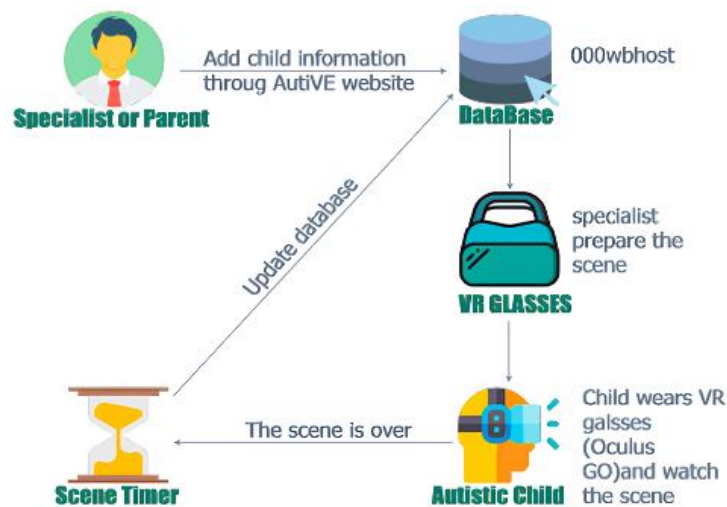


Figure 2. System architecture for AutiVE system

2. PROPOSED METHOD

2.1. Overview

To address this problem, we proposed integrating VR technology with ABA, specifically DTT, to create immersive training sessions tailored to children with ASD. These sessions will simulate realistic earthquake scenarios, allowing children to learn and practice appropriate responses in a safe, controlled environment. Key components of our solution include:

- Immersive 3D visual simulations: these realistic simulations replicate earthquake scenarios, incorporating sensory elements like sights, sounds, and physical sensations to create a comprehensive learning experience.
- ABA-based training: rooted in ABA principles, particularly DTT, the sessions emphasize clear, structured instructions, reinforcement, and repetition to suit the needs of children with ASD during earthquake drills.
- Assessment and progress tracking: progress tracking and data collection will measure each child's development in earthquake preparedness, ensuring tailored support and adaptability.

This approach combines the immersive, experiential benefits of VR with the structured, evidence-based ABA framework. The resulting program is systematic, adaptable, and geared toward equipping children with ASD for real-world earthquake safety, enhancing both their preparedness and confidence.

2.2. Procedure

Our procedure was divided into three steps, described in the following paragraphs. Each step is based on the drop, cover, and hold on (DCH) method—a widely recommended approach for maintaining safety during an earthquake [15]. The primary objective of DCH is to minimize injury risk by seeking shelter behind sturdy furniture to avoid falling objects [16], [17]. DCH is endorsed by numerous organizations as the standard response to seismic events [18]–[20], making it an effective choice for guiding children with ASD in appropriate earthquake response behaviors.

In the first step, “earthquake recognition”, participants are placed in a virtual room where earthquake simulations are introduced. A prompt appears, asking participants to identify if the scenario is an earthquake by selecting “yes” or “no”. Correct answers are highlighted to reinforce learning. This step assesses participants’ ability to accurately recognize earthquake situations. The second step was responding to the cue “Protect the head”. Participants had to verbally describe the action they should take to protect their heads effectively during an earthquake. This step focuses on teaching participants appropriate safety responses and reinforces the importance of protective measures during seismic events. The final trial introduced the command “hide under the table”. Participants had to describe the action of hiding under a table in response to the cue to pass the trial. This step emphasizes the importance of seeking appropriate shelter during earthquakes and reinforces the safety protocol of DCH. A brief synopsis of the sequential phases required in the training process is shown in Figure 3, which graphically depicts the procedural framework of the VR-based system approaches covered in this part.

Flexible prompt fading, a vital technique in DTT, was applied to consolidate participant responses in all three steps. These involved trainers using their judgment to select appropriate prompts, if necessary, for each trial. For example, in the “protect the head” step, trainers could choose from options like showing a video, displaying an image, or physically guiding the child’s hands to their head. Given the novelty of VR technology and its unique challenges, we opted for a dynamic approach over a static prompting hierarchy. Feedback was provided in two ways: immediate feedback from the VR base and trainer-deliver feedback. In the first form, when the participant successfully performs the task required, a congratulatory message and joyful sound are displayed after each step, and access to the preferred activity (e.g., games or videos on the headset) after each session based on the participant’s preference. In addition, the experimenter provided verbal praise for correctly performed behaviors and corrective verbal feedback for skill components that needed improvement at the end of the trial.

2.3. VR application

Based on our procedure, we have developed a VR application designed to carry out the settings, and trials to assist autistic children. The first scene serves as the foundation setting for participants to familiarize themselves with the virtual environment before delving into earthquake-specific scenarios. In the VR familiarization session, a lifelike scene as illustrated in Figure 4 with interactive toys and objects, designed to make participants feel like they were in a comfortable, colorful room was presented. Some highlight features in the room are a table, a shelf displaying various items, and a glass window, which were programmed to simulate falling and breaking in the earthquake scenario, creating dynamic and engaging visual cues.

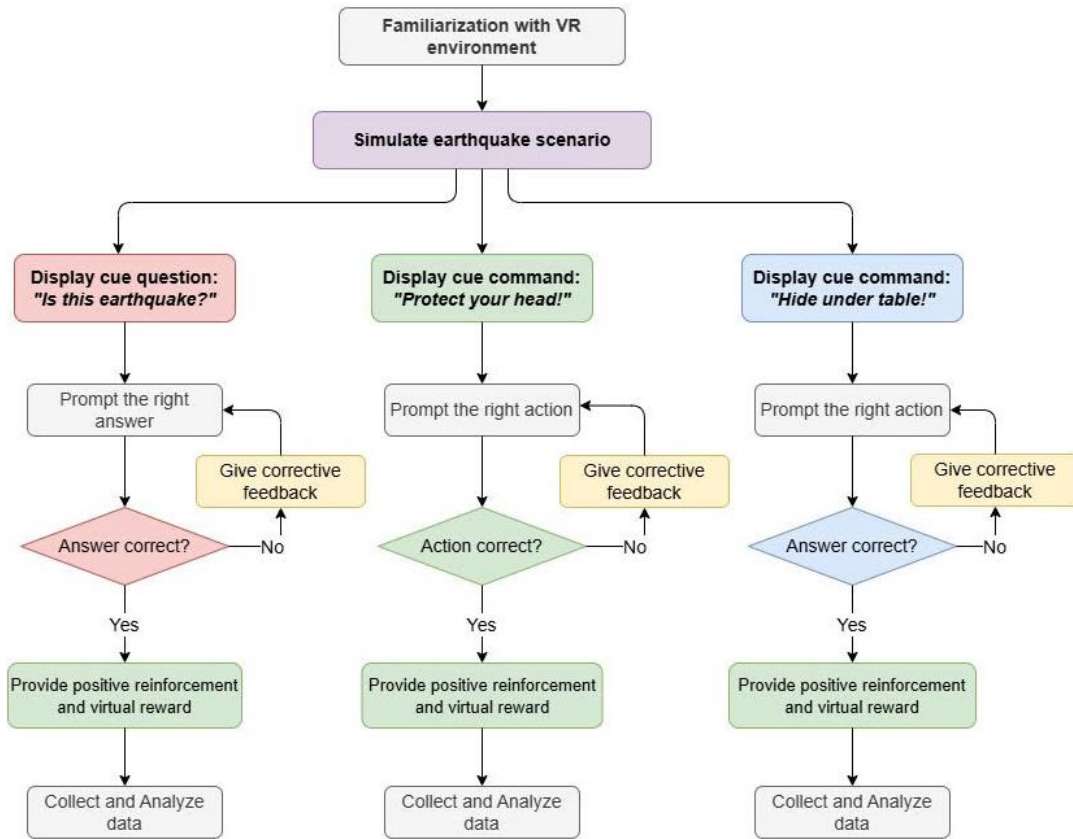


Figure 3. Procedure of the VR-based system and ABA methods, highlighting sequential steps in the training process



Figure 4. VR base scene

After 5 to 10 minutes of getting used to the environment, the trainer will start the earthquake simulation. Participants would have 10 seconds to observe the shaking effect and object falling. Then our three steps in the procedure including “earthquake recognition”, “protect the head”, and “hide under the table” would take place. The study assessed autistic children’s performance using a VR motion controller. In the initial step, the correct response involved moving the controller correctly. “Protect the head” required the controllers to touch at head level. In the final step, “hide under the table” participants had to lower and move the controller to reach a virtual table as in Figure 5. Correctness and response time were recorded for each action. Based on this data, the trainer could progress or repeat steps, and different prompt types (video, image, audio, or none) were available at each level.

In the development of our VR earthquake safety program for children with autism, we tailored our approach to accommodate their distinctive perceptual characteristics. To achieve this, we implemented localized prompts within our application to effectively guide their attention. For example, in “protect the

head” (step 2), we incorporated a clear image within the VR scene. Visual salience techniques like color contrast and motion highlighted important elements. When introducing “hide under the table” (step 3), we emphasized the table’s attributes and used visual cues to guide participants to its location, improving their understanding. Our approach enhances the effectiveness of earthquake safety training for children with autism. Moreover, we have taken into consideration sensory sensitivities by providing options to adjust sensory input within the VR environment, such as sound volume and brightness. Figure 6 illustrates these features. To further enhance the training’s effectiveness, data collection was integrated into the program to track how participants perceive and respond to various elements. Lastly, to provide suitable settings, we sought consultation with experts in autism and sensory processing to ensure that our VR application aligns with the latest research findings and best practices in this field.



Figure 5. Hide under table step



Figure 6. VR options menu panel

2.4. Experiments

2.4.1. Participants

The 30 children, aged 3 to 9 (18 males and 12 females), participated in the study at Hanoi ASD Center. Informed consent was obtained from parents and participants. Diagnoses of Asperger syndrome or PDD-NOS were confirmed using the autism diagnostic observation schedule (ADOS). Exclusion criteria included acute psychiatric conditions, Axis I psychopathology (except managed ADHD), or neurological disorders. The 12 children had comorbid ADHD, enabling secondary analyses. All participants had IQs in the average-to-above-average range. Ethical consent processes were followed, and the study assessed the effectiveness of a VR-based earthquake safety program within the DTT framework. The demographic variables are depicted in Table 1.

Table 1. Means and standard deviations for demographic variables

Variables	Total (N=30)	ASD only (N=18)	ASD+ADHD (N=12)
Males: females	18:12	10:8	8:4
Age (years)	6.7 (2.4)	6.9 (2.3)	7.6 (1.9)
Estimated IQ (standard score)	90.0 (10.0)	87.5 (9.0)	94.0 (11.0)
Vocabulary (t-score)	58.5 (10.0)	57.8 (9.6)	60.2 (10.9)
Matrix reasoning (t-score)	58.1 (6.2)	57.3 (6.4)	60.4 (5.8)

2.4.2. Environment setting

The research was conducted at the Ha Noi ASD Center's Research Laboratory, where participants were introduced to VR equipment, including Oculus Rift glasses, a keyboard, a mouse, and handheld devices. The software, a publicly accessible 3D virtual world application, was pre-installed on devices before the study. The VR environment ran on a computer with Microsoft Windows 10, an NVIDIA GeForce RTX 3090 graphics card, and an Intel Core i9 CPU. The software was displayed on a 24-inch Dell Ultrasharp monitor with a resolution of 1920×1200, chosen to enhance the immersive experience of the training sessions.

3. RESULTS AND DISCUSSION

Figure 7 presents the results from our training program, showcasing the participants' performance in terms of correct, incorrect, and non-responses across sessions. Initial accuracy was low, with only 20% of correct responses in the first session. However, performance steadily improved, reaching approximately 80% accuracy by the 12th session. This trend demonstrates the potential of VR to augment ABA methods, which are already recognized for their effectiveness in interventions for children with ASD. The graph now includes clear axis labels: the vertical axis represents the percentage of response accuracy (correct, incorrect, and no responses), while the horizontal axis corresponds to the training sessions, ensuring clarity for readers. These findings align with previous studies [7], [21], [22], which highlight the capacity of VR to develop essential skills and build confidence in individuals with ASD. Although accuracy levels in our study were slightly lower than some ABA-specific interventions [6], [23]–[25], the reduction in incorrect responses—from 45% to 20% by the final session—emphasizes the program's impact.

The observed differences in performance can be attributed to several factors. First is adaptation to VR technology. Participants required an adjustment period to familiarize themselves with the novel VR environment, which may have contributed to the lower accuracy during initial sessions. This contrasts with more established methods like traditional ABA or behavioral skills training (BST) [23], [26], [27]. Secondly are sample size and participant variability. Compared to earlier studies with smaller cohorts, our sample size of 30 participants enhances generalizability but introduces variability in participant characteristics, such as age, sensory sensitivities, and comorbid conditions, potentially influencing outcomes.

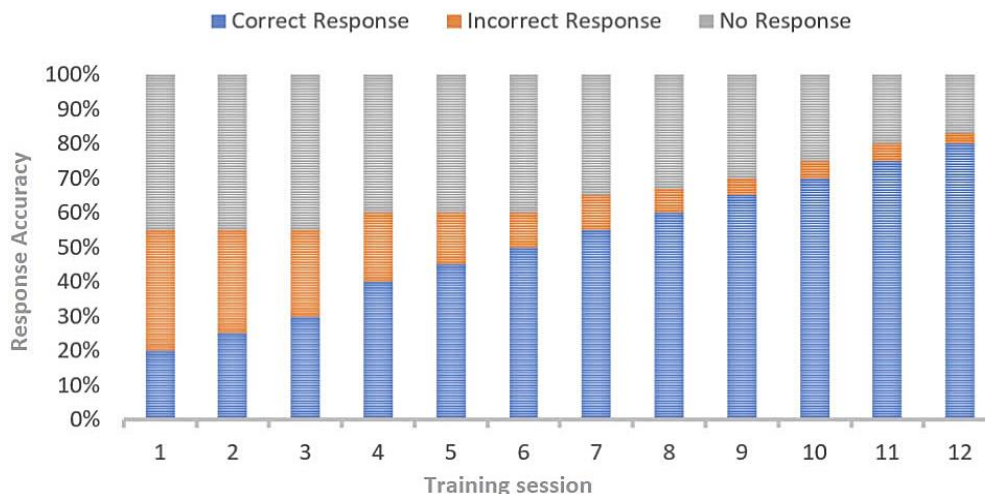


Figure 7. Outcome results of all training sessions

The combination of ABA principles and immersive VR simulations effectively addresses the critical safety needs of children with ASD, particularly in preparing for seismic events. This approach balances the immersive realism of VR with the structured reinforcement techniques of ABA, tackling a significant challenge in traditional safety training—providing realistic, yet controlled, learning environments [24], [25], [28]–[30]. Given the increasing prevalence of natural disasters, equipping children with foundational safety skills is more important than ever. While the findings are promising, certain limitations should be acknowledged. First, the sample composition, the inclusion of participants with diverse characteristics (e.g., ASD with and without ADHD) may affect the uniformity of results. Future studies could focus on more homogenous groups to refine insights. Secondly, training duration. The optimal duration for achieving the best outcomes in VR-based training remains unclear. Controlled studies comparing VR and ABA methods

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with similar durations could provide further clarity. Finally, VR module design. Investigating specific design elements, such as prompt timing, sensory adjustments, and interaction methods, may yield improvements in training efficacy.

Future research should also explore extending this approach to other safety contexts, such as fire evacuation or abduction prevention, to broaden its applicability. Personalized interventions tailored to individual participant needs, supported by advanced VR features, could further enhance learning outcomes. In conclusion, this study demonstrates that integrating VR technology with ABA methods offers a viable and innovative approach to enhancing earthquake preparedness in children with ASD. By addressing the unique learning needs of this population, the program provides a safe and controlled environment to practice critical safety skills. As natural disasters become more frequent, this research underscores the importance of adopting advanced educational tools in special education. Educators, therapists, and policymakers are encouraged to incorporate VR-based ABA training into their programs, improving safety outcomes and reducing anxiety in emergencies.

4. CONCLUSION

This research successfully integrates VR and ABA, specifically DTT, to address a critical gap in disaster preparedness for children with ASD. Key findings reveal substantial progress in earthquake response behaviors, affirming the effectiveness of immersive learning environments tailored to ASD children's needs. Practical contributions include a customizable VR platform that balances realism and safety, providing a replicable model for educators and therapists. Future work should explore cost-effective implementations to make VR-based safety training more accessible. Additionally, expanding this approach to diverse emergency scenarios can further validate its impact. By equipping ASD children with essential safety skills, this innovative method bridges the gap between theoretical research and real-world application, fostering independence and reducing anxiety in critical situations.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Dao Thi Thu		✓		✓		✓	✓	✓	✓	✓			✓	
Giap Minh Hieu		✓	✓	✓			✓	✓	✓	✓	✓	✓		
Nguyen Van Cuong		✓			✓				✓	✓	✓			
Do Van Viet					✓		✓		✓	✓	✓	✓		
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C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors also confirm that there are no non-financial competing interests, including political, personal, religious, ideological, academic, or intellectual conflicts. Authors state no conflict of interest.

DATA AVAILABILITY

The data supporting the findings of this study were collected from experimental sessions conducted with children with ASD at several specialized education centers in Hanoi, Vietnam, within real-world learning environments. Due to ethical considerations and the protection of participant privacy, the dataset is not publicly available. However, anonymized data may be made available from the corresponding author, [TBN], upon reasonable request and with appropriate institutional approval.




REFERENCES

- [1] American Psychiatric Association, "Neurodevelopmental disorders," in *Diagnostic and statistical manual of mental disorders: DSM-5-TR*, Washington D.C.: American Psychiatric Association, 2022.
- [2] G. N. Soke, M. J. Maenner, D. Christensen, M. Kurzius-Spencer, and L. A. Schieve, "Prevalence of co-occurring medical and behavioral conditions/symptoms among 4- and 8-year-old children with autism spectrum disorder in selected areas of the United States in 2010," *Journal of Autism and Developmental Disorders*, vol. 48, no. 8, pp. 2663–2676, 2018, doi: 10.1007/s10803-018-3521-1.
- [3] J. Calver, R. Balogh, and D. Rudoler, "Incidence of injury in children and adolescents with intellectual and developmental disability," *Journal of Safety Research*, vol. 77, pp. 56–60, 2021, doi: 10.1016/j.jsr.2021.02.003.
- [4] L. Zhou, S. L. Porterfield, S. Fang, J. Huang, and Y. Zhang, "Unintentional injuries among children with developmental disabilities are a public health challenge in China," *Child: Care, Health and Development*, vol. 49, no. 6, pp. 1054–1057, 2023, doi: 10.1111/cch.13115.
- [5] J. Santos-Reyes, *Introductory chapter: earthquakes-impact, community vulnerability, and resilience', earthquakes-impact, community vulnerability and resilience*. IntechOpen, Sep. 11, 2019, doi: 10.5772/intechopen.86284.
- [6] R. Bergstrom, A. Najdowski, and J. Tarbox, "Teaching children with autism to seek help when lost in public.," *Journal of applied behavior analysis*, vol. 45, no. 1, pp. 191–195, 2012.
- [7] A. M. Kum and H. Bilmez, "Teaching home safety skills to children with autism spectrum disorders," *Frontiers in Psychiatry*, vol. 16, 2025, doi: 10.3389/fpsy.2025.1688922.
- [8] A. P. da Silva, I. M. P. Bezerra, T. P. C. Antunes, M. P. E. Cavalcanti, and L. C. de Abreu, "Applied behavioral analysis for the skill performance of children with autism spectrum disorder," *Frontiers in Psychiatry*, vol. 14, 2023, doi: 10.3389/fpsy.2023.1093252.
- [9] T. Eckes, U. Buhlmann, H. D. Holling, and A. Möllmann, "Comprehensive ABA-based interventions in the treatment of children with autism spectrum disorder – a meta-analysis," *BMC Psychiatry*, vol. 23, no. 1, 2023, doi: 10.1186/s12888-022-04412-1.
- [10] D. R. Dixon, C. J. Miyake, K. Nohely, M. N. Novack, and D. Granpeesheh, "Evaluation of an immersive virtual reality safety training used to teach pedestrian skills to children with autism spectrum disorder," *Behavior Analysis in Practice*, vol. 13, no. 3, pp. 631–640, 2019, doi: 10.1007/s40617-019-00401-1.
- [11] Y. Dan, "Potential application of virtual reality in ASD intervention," *Highlights in Science, Engineering and Technology*, vol. 46, pp. 162–175, 2023, doi: 10.54097/hset.v46i.7698.
- [12] M. Sait, A. Alattas, A. Omar, S. Almalki, S. Sharf, and E. Alsaggaf, "Employing virtual reality techniques in environment adaptation for autistic children," *Procedia Computer Science*, vol. 163, pp. 338–344, 2019, doi: 10.1016/j.procs.2019.12.116.
- [13] T. Smythe, N. Scherer, C. Nanyunja, C. J. Tann, and B. O. Olusanya, "Strategies for addressing the needs of children with or at risk of developmental disabilities in early childhood by 2030: a systematic umbrella review," *BMC Medicine*, vol. 22, no. 1, 2024, doi: 10.1186/s12916-024-03265-7.
- [14] A. Anwar, R. Sutadi, and C. Miranda, "Development of discrete trial training (DTT) procedure in smart applied behavior analysis (Smart ABA) for autism," *Journal of Psychology and Behavior Studies*, vol. 2, no. 1, pp. 63–44, 2022, doi: 10.32996/jpbs.2022.2.1.7.
- [15] C. Li, W. Liang, C. Quigley, Y. Zhao, and L. F. Yu, "Earthquake safety training through virtual drills," *IEEE Transactions on Visualization and Computer Graphics*, vol. 23, no. 4, pp. 1275–1284, 2017, doi: 10.1109/TVCG.2017.2656958.
- [16] M. F. Celikmen, S. Yilmaz, A. C. Tatliparmak, and F. Unal Colak, "Drop, cover, and hold on versus fetal position in the triangle of life to survive in an earthquake: a Delphi study," *Prehospital and Disaster Medicine*, vol. 38, no. 3, pp. 287–293, 2023, doi: 10.1017/S1049023X23000444.
- [17] P. V. Kammer, J. S. Moro, J. P. Soares, C. Massignan, C. M. G. Phadraig, and M. Bolan, "Prevalence of tooth grinding in children and adolescents with neurodevelopmental disorders: a systematic review and meta-analysis," *Journal of Oral Rehabilitation*, vol. 49, no. 6, pp. 671–685, 2022, doi: 10.1111/joor.13315.
- [18] L. Widyusuf, M. Muktiarni, and J. Mupita, "Earthquake disaster preparedness for students of junior high school," *ASEAN Journal of Science and Engineering Education*, vol. 2, no. 2, pp. 129–136, 2022, doi: 10.17509/ajsee.v2i2.38679.
- [19] M. M. Rahman *et al.*, "Earthquake preparedness in an urban area: the case of Dhaka city, Bangladesh," *Geoscience Letters*, vol. 10, no. 1, 2023, doi: 10.1186/s40562-023-00281-y.
- [20] G. D. Brown, A. Largey, C. McMullan, and P. Daffy, "Fire safety protection motivation and preparedness in Irish apartments: a post-grenfell analysis," *Safety Science*, vol. 148, 2022, doi: 10.1016/j.ssci.2021.105630.
- [21] J. Guan and G. Li, "Injury mortality in individuals with autism," *American Journal of Public Health*, vol. 107, no. 5, pp. 791–793, 2017, doi: 10.2105/AJPH.2017.303696.
- [22] F. Zhang, Z. Xu, Y. Yang, M. Qi, and H. Zhang, "Virtual reality-based evaluation of indoor earthquake safety actions for occupants," *Advanced Engineering Informatics*, vol. 49, p. 101351, 2021, doi: 10.1016/j.aei.2021.101351.
- [23] K. R. Choi *et al.*, "Patient outcomes after applied behavior analysis for autism spectrum disorder," *Journal of Developmental and Behavioral Pediatrics*, vol. 43, no. 1, pp. 9–16, 2022, doi: 10.1097/DBP.0000000000000995.
- [24] A. C. F. da Silva, T. de S. Barbosa, and M. B. D. Gavião, "Parental perception of the oral health-related quality of life of children and adolescents with autism spectrum disorder (ASD)," *International Journal of Environmental Research and Public Health*, vol. 20, no. 2, 2023, doi: 10.3390/ijerph20021151.
- [25] A. Bonnel, L. Mottron, I. Peretz, M. Trudel, E. Gallun, and A. M. Bonnel, "Enhanced pitch sensitivity in individuals with autism: a signal detection analysis," *Journal of Cognitive Neuroscience*, vol. 15, no. 2, pp. 226–235, 2003, doi: 10.1162/089892903321208169.




- [26] A. Gentil-Gutiérrez *et al.*, “Executive functions in children and adolescents with autism spectrum disorder in family and school environment,” *International Journal of Environmental Research and Public Health*, vol. 19, no. 13, 2022, doi: 10.3390/ijerph19137834.
- [27] Y. X. Zhang and J. R. Cummings, “Supply of certified applied behavior analysts in the United States: implications for service delivery for children with autism,” *Psychiatric Services*, vol. 71, no. 4, pp. 385–388, 2020, doi: 10.1176/appi.ps.201900058.
- [28] R. G. Miltenberger and M. A. Novotny, “Teaching Safety Skills to Individuals with Developmental Disabilities,” *Advances in Neurodevelopmental Disorders*, vol. 6, no. 3, pp. 270–279, 2022, doi: 10.1007/s41252-022-00248-8.
- [29] F. J. Alves, E. A. De Carvalho, J. Aguilar, L. L. De Brito, and G. S. Bastos, “Applied behavior analysis for the treatment of autism: a systematic review of assistive technologies,” *IEEE Access*, vol. 8, pp. 118664–118672, 2020, doi: 10.1109/ACCESS.2020.3005296.
- [30] B. Rosello, C. Berenguer, I. Baixauli, R. Garcia, and A. Miranda, “Theory of mind profiles in children with autism spectrum disorder: adaptive/social skills and pragmatic competence,” *Frontiers in Psychology*, vol. 11, 2020, doi: 10.3389/fpsyg.2020.567401.

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