



Exploring a VR safety training prototype for active shooting emergency preparedness: Demonstration and preliminary evaluation

Daniel Zuniga-Vazquez and Ren Boz

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Abstract

Introduction. Immersive experiences through virtual reality (VR) offer opportunities to create authentic yet safe learning environments for high-stakes training contexts. In this paper, we present a serious game virtual reality safety training prototype for active shooting emergencies in schools, titled *Second Chance*. This gamified training application aims to improve students' decision-making during active shooter emergencies based on the ALICE (alert, lockdown, inform, counter, and evacuate) method.

Method. The prototype was developed for Oculus Go, with game mechanics such as progressive level design, interactive tutorial, NPC collaboration, and performance-based progression.

Analysis. We conducted pre- and post-training questionnaires (N = 18) measuring anxiety, motivation, readiness, usability, presence, and perceived effectiveness.

Results. Results showed low pre-training anxiety levels (M = 2.236), moderate to high pre-training motivation (M = 3.861) and post-training perceived training effectiveness (M = 3.824) on a 5-point scale relative to the scale midpoint.

Conclusion. This preliminary evaluation demonstrates the prototype's potential as an entry-level ALICE training tool and provides insights for future comprehensive serious games and gamified VR training research in educational emergency preparedness contexts.

Introduction

Active shooter incidents pose a growing threat to American society, with 4,011 mass shootings reported between 2014-2022 (Barnard et al., 2023). Approximately 25% of active shooter incidents occur in educational settings (Federal Bureau of Investigation, 2014), making student preparedness crucial. From 2000 through 2022, there were 50 active shooter incidents at elementary and secondary schools and 18 at postsecondary institutions. At K-12 schools alone, these incidents resulted in 328 casualties, including 131 fatalities and 197 injuries (National Center for Education Statistics, 2024). These incidents typically last 5 to 19 minutes, with the deadliest phase occurring within the first 10 minutes, emphasising the critical importance of immediate response preparedness (ALICE Training Institute, 2024). The ALICE method (alert, lockdown, inform, counter, evacuate) provides a proactive framework for active shooter response training (<http://www.alicetraining.com>).

Serious games offer significant advantages for safety education, providing immersive experiences without real-world risks while leveraging game mechanics to enhance engagement and learning retention. Virtual reality (VR) has demonstrated effectiveness in various domains, such as construction safety (Sacks et al., 2013), firefighting (Narciso et al., 2020), and emergency response training (Carlson & Caporusso, 2018). Game-based learning approaches have shown particular promise in high-stress training scenarios, such as emergency medical training (Karakuş et al., 2014) and military simulations (Samcović, 2018), where traditional methods may induce anxiety that impairs learning (Clark & Mayer, 2013).

Immersive experiences in educational contexts have been shown to enhance learning retention through embodied cognition and spatial presence (Radianti et al., 2020). Unlike traditional media, VR creates what Slater (2009) calls 'place illusion', which can be described as the sense of being in a virtual environment rather than observing it. This becomes particularly valuable in emergency preparedness training, where traditional drills often fail to replicate the stress and decision-making complexity of real scenarios and may also induce trauma (Zhe & Nickerson, 2007). Immersive VR environments can bridge this gap by providing authentic experiential learning without real-world consequences.

Emergency preparedness training presents unique game design challenges: maintaining realism while avoiding trauma and creating engaging yet respectful scenarios. *Second Chance*, a serious game VR prototype implementing ALICE methodology for student training, is discussed in this paper to contribute to the limited research on serious games for active shooter preparedness in educational settings. The prototype incorporates game design principles and interactive mechanics, with preliminary evaluation results obtained from a mixed-format evaluation approach.

While prior VR-based active shooter training systems have primarily focused on professional populations or emphasised realism over accessibility, this work specifically targets student preparedness through an entry-level implementation of the ALICE framework. By combining serious game design principles with low-cost, standalone VR hardware, *Second Chance* contributes a student-centered VR training prototype for active shooter preparedness as well as a preliminary evaluation that offers early insights into engagement, anxiety, and perceived training effectiveness.

Related work

Recent research has explored serious games and VR applications for active shooter training. Griffith et al. (2017) developed a multi-user virtual environment for training teachers and staff, offering role-playing scenarios with real-time observation capabilities. Lovreglio et al. (2022) tested a VR serious game counterterrorism prototype in university settings, showing increased knowledge, motivation, and self-efficacy. Liu et al. (2023) compared video-based, low-interactivity

VR, and high-interactivity VR training, finding that higher interactivity levels, which is a core game design principle, significantly improved training effectiveness.

It has been established that interactivity and player agency are crucial aspects for effective learning games (Dondlinger, 2007). Studies in VR training have demonstrated that virtual learning applications benefit from clear progression systems, immediate feedback mechanisms, and collaborative gameplay elements (Radianti et al., 2020; Petersen et al., 2023).

Recent research has highlighted the importance of comprehensive evaluation methodologies for serious games and VR training systems, including both immersive VR experiences and comparative video-based assessments to understand the unique contributions of interactive game elements (Tcha-Tokey et al., 2016; Chang et al., 2023).

Commercial gamified VR safety training applications have also emerged in the literature (Environmental Tectonics Corporation, 2024; Sisu VR Inc., 2024), but few specifically address the ALICE methodology in educational contexts using evidence-based game design principles. Our work contributes to the serious games literature by focusing specifically on ALICE implementation for student populations using budget-friendly hardware while incorporating established game mechanics.

Prototype design and implementation

Game design and technical implementation

Second Chance was developed using Unity for Oculus Go, utilising free Unity Asset Store resources. The game includes progressive difficulty and guided learning. Due to processing limitations, low-poly assets were used, which were compensated with enhanced audio design and lighting effects. Interactive game mechanics included object manipulation (e.g., moving chairs and tables to construct barricades) and continuous steering-based locomotion for navigation.

Our prototype was designed around key principles for educational immersion, including embodied agency, multi-modal engagement, and social presence through non-player characters (NPCs). Players physically manipulated virtual objects (e.g., furniture for barricades), fostering kinesthetic memory formation that supports transfer of skills from the virtual to the real world. The seven-level progression structure enabled participants to gradually build familiarity and comfort with the virtual environment before encountering high-stress scenarios, supporting presence development through repeated exposure. We emphasised enhanced audio to compensate for visual limitations in our design, using spatial audio cues to guide player attention and create environmental awareness. We included NPCs to promote social presence through collaborative decision-making, mirroring emergency scenarios that require coordinated group response. Swarm AI mechanics further simulated group dynamics under stress, strengthening the authenticity of the training experience.

Key game features included tutorial-based onboarding with guided practice, immediate feedback systems through visual and audio cues, progressive skill building across sequential levels, collaborative NPC interactions requiring strategic decision-making, and performance assessment through timed challenges. Players could repeat scenarios to improve performance without real-world consequences. The virtual environment featured a school building with classrooms, hallways, and common areas to enable ALICE training (Figure 1).

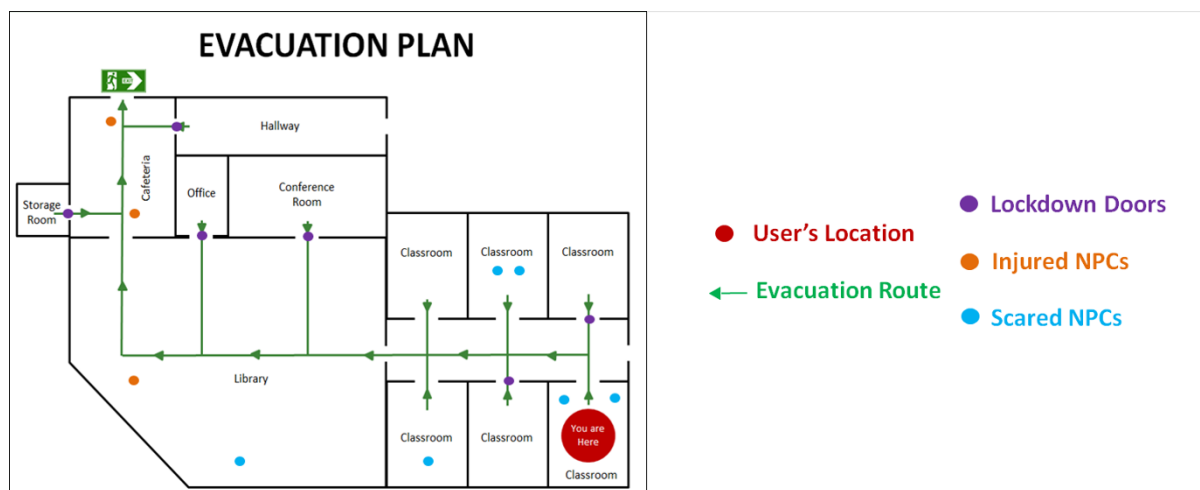


Figure 1. Virtual environment layout showing the multi-room school building design with classrooms, hallways, and common areas used for ALICE training scenarios.

ALICE-based gameplay progression

The serious game consisted of seven progressively challenging levels implementing each of the ALICE components to provide entry-level training. The **Tutorial** provided a gamified introduction to VR controls through interactive challenges and voice-guided instructions. **Alert** included role-playing scenarios where players informed NPCs about emergency situations, receiving score feedback based on the number of people alerted and time efficiency (Figure 2a). **Lockdown** implemented physics-based gameplay where players created barricades by dragging furniture, with progress bars providing immediate feedback (Figure 2b). **Inform** featured decision-making gameplay where players interacted with NPCs to gather information and made collective decisions, implementing branching narrative elements (Figure 2c). **Counter** provided coordinated team-based gameplay where players collaborated with NPCs using swarm AI mechanics to approach threats (Figure 2d). **Evacuate** combined tool use (breaking windows) and pathfinding challenges to create escape routes (Figure 2e). **Survival** served as the final assessment, requiring players to complete all ALICE objectives within 200 seconds while tracking completion time, objectives achieved, and NPCs saved (Figure 2f). Game design considerations included deliberately avoiding direct gunshot visuals and minimising blood effects to reduce the risk of trauma while maintaining training effectiveness.

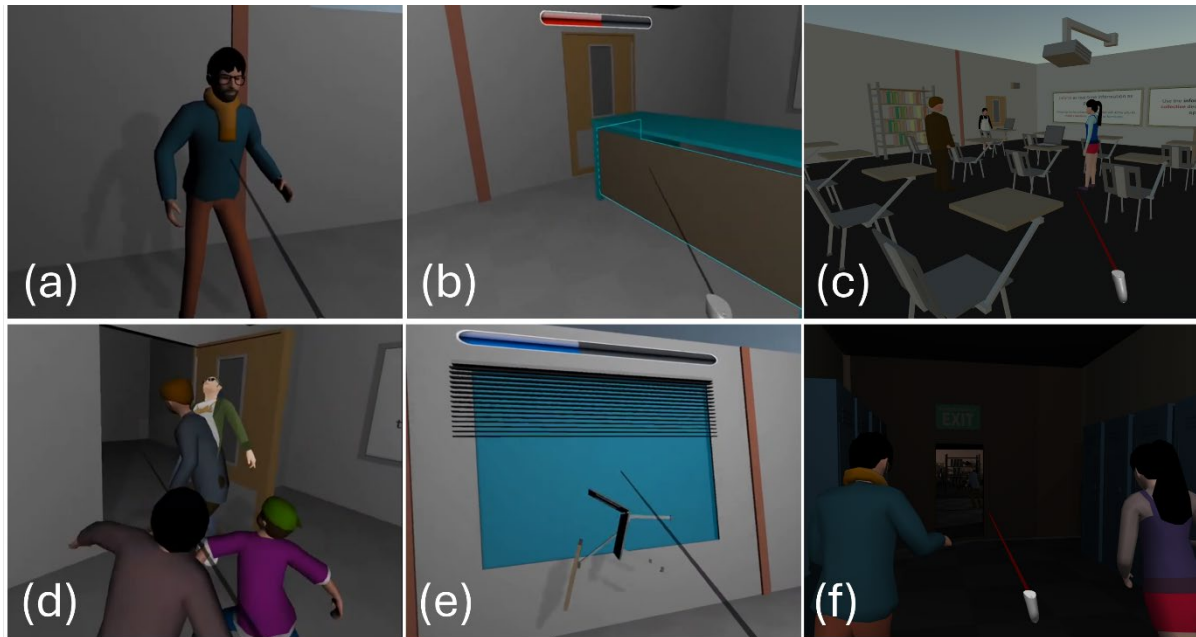


Figure 2. Gameplay screenshots from the *Second Chance* VR prototype.

Evaluation methodology

Serious game evaluation design

We employed an immersive experience evaluation framework, using pre- and post-training questionnaires measuring anxiety, motivation, readiness, usability, presence, and perceived effectiveness on 5-point Likert scales (5 = strongly agree, 1 = strongly disagree). The evaluation framework incorporated established game user research methodologies, including player experience assessment and gameplay effectiveness metrics commonly used in serious games evaluation (Wouters et al., 2013).

Participants and questionnaire

Eighteen university students participated in the evaluation (3 female, 14 male, 1 non-binary; ages 23 to 41, $M = 28.4$, $SD = 4.78$) with IRB approval from the University of Arizona. The prototype evaluation included university-level students as a starting population before potential adaptation for younger learners, as this demographic allows for initial safety testing while avoiding potential trauma concerns with minors.

Due to COVID-19 restrictions in place at the time of the study, only 3 participants could experience full VR training using personal Oculus Go headsets, while 15 participants watched pre-recorded comprehensive gameplay videos. Both groups completed identical questionnaires, resulting in a mixed-format evaluation approach.

The specific questionnaire items used in our evaluation measured multiple dimensions across pre-training and post-training phases. Pre-training measures included anxiety items: 'I feel stressed about this training session', 'I feel tense about attending this training session', 'I do not feel mentally ready/prepared for this training session', and 'I am worried about how I am going to perform in this training session'. Motivation items included: 'I am motivated to do this training', 'I want to succeed in this training', 'I am confident that I can do well in this training', and 'I am excited to participate in this training course because the training environment is different'. Readiness items assessed: 'I feel active right now', 'I feel mentally alert right now', 'I am aware of everything happening around me

right now', 'I am fully conscious right now', 'I am/feel competitive', and 'I feel that I am in control of the situation'.

Post-training measures assessed the usability of instructions with questions: 'Clear goals, objectives, and outcomes are communicated at the beginning of the training program', 'There is consistency in the sequence of actions taken in similar situations', and 'Objects, options, and permissible actions are visible so that users do not have to remember instructions'. Usability of interaction questions included: 'It was easy to move in the virtual environment', 'Input devices were easy to use and easy to control', and 'I thought the interaction device (Oculus Go headset) was easy to use'. Presence was measured using: 'I felt as if I was part of the virtual environment and not isolated from it', 'The virtual environment displayed adequate levels of realism', 'The virtual environment was responsive to actions that I initiated', 'I could examine objects from multiple viewpoints', 'The device (Oculus Go controller) that controlled my movement distracted me from performing assigned tasks' (reverse-scored), and 'The user was able to interact with, or control, the virtual environment in a natural manner'. Training effectiveness items included: 'Virtual reality enhanced my learning', 'Using virtual reality as a training environment has improved the quality of my training', 'This virtual reality training has improved my knowledge', 'I consider I gained enough knowledge and experience from this training session to perform well in case of a future active shooter emergency', 'The virtual reality training environment is a useful tool to train students how to deal with school active shooter emergencies' and 'Overall, I am satisfied with the virtual reality training'. All items used 5-point Likert scales (1 = strongly disagree, 5 = strongly agree), plus one open-ended question: 'Is there anything that you liked/disliked or would like to suggest related to your experience?'

Results

Pre-training results

Participants reported low anxiety levels when anticipating training ($M = 2.236$, $SD = 0.811$) relative to the neutral midpoint of the 5-point Likert scale, contrasting with research showing traditional active shooter drills induce stress (Zhe & Nickerson, 2007). Motivation was above average ($M = 3.861$, $SD = 0.439$), as was readiness ($M = 3.574$, $SD = 0.512$). Detailed descriptive statistics for all pre-training measures are presented in Table 1.

Measure	N	Mean	Std. Error	Median	Std. Dev.	Cronbach's α
Pre-Training						
Anxiety	18	2.236	0.191	2.125	0.811	0.890
Motivation	18	3.861	0.103	3.750	0.439	0.483
Readiness	18	3.574	0.121	3.667	0.512	0.723
Post-Training						
Usability Instructions	18	3.870	0.138	4.000	0.585	0.759
Usability Interaction	18	3.426	0.110	3.667	0.469	0.516
Presence	18	3.352	0.127	3.333	0.539	0.709
Training Effectiveness	18	3.824	0.117	3.917	0.497	0.699

Table 1. Descriptive statistics for pre-training and post-training measures.

Post-training results

Usability ratings were moderate to high for instruction clarity ($M = 3.870$, $SD = 0.585$) and interaction ease ($M = 3.426$, $SD = 0.469$) relative to the neutral midpoint of the 5-point Likert scale. Lower Cronbach's α values for the Motivation and Usability Interaction measures suggest greater item heterogeneity and warrant cautious interpretation of these results in this preliminary study. Despite technical constraints, participants reported moderate to high presence levels ($M = 3.352$, $SD = 0.539$), highlighting the importance of compensating with other available modalities when

faced with hardware limitations. The audio-enhanced environment contributed significantly to presence, with participants noting ‘very immersive soundscape’ in qualitative feedback. Perceived training effectiveness was also reported as moderate to high ($M = 3.824$, $SD = 0.497$), indicating that participants believed the training improved their preparedness and knowledge. Complete descriptive statistics for all post-training measures are shown in Table 1. The complete distribution of pre-training and post-training questionnaire results is shown in Figure 3.

The mixed-format evaluation revealed distinct patterns: VR participants focused on interaction mechanics and presence, while video participants emphasised content structure and scenario flow. These differences suggest that immersive experiences elicit fundamentally different cognitive processing patterns, supporting embodied cognition theories in emergency preparedness education, which argue that learning is grounded in bodily action and perception (Slater, 2009).

Player experience and game feedback

Participants praised the game's audio design for enhancing realism and highlighted the logical gameplay progression through the ALICE methodology. Video participants focused on the game content structure and scenario flow, while VR participants provided detailed feedback for interaction mechanics and presence. Key suggestions included adding more progress indicators and achievement systems and enhancing visual fidelity. From a game design perspective, participants appreciated the non-violent approach to serious content and the collaborative NPC mechanics. Representative comments included: ‘I feel it will be a great tool for learning the best way to act in this stressful situation’ (VR participant); ‘Very immersive soundscape’ (gaming audio design); ‘This is a really awesome and useful game; however, it should be used as a support. I believe that real training sessions are necessary’ (video participant).

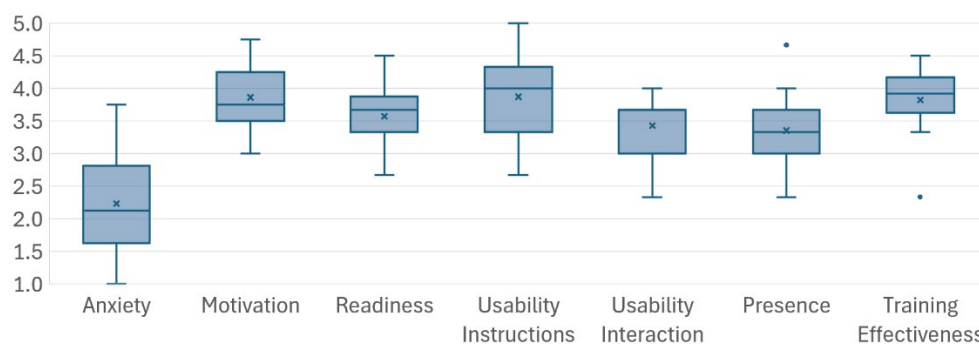


Figure 3. Box plots showing distributions of all questionnaire results ($N = 18$), including pre-training measures (anxiety, motivation, readiness) and post-training measures (usability, presence, training effectiveness) across presentation formats.

Discussion and limitations

Serious game validation

The preliminary evaluation demonstrates three promising aspects: low anxiety induction compared to traditional drills, high perceived training effectiveness (relative to the neutral midpoint of the 5-point Likert scale) across the two presentation formats (VR and video), and user acceptance. The prototype was successful in balancing serious content with engaging mechanics while maintaining player engagement.

Our findings align with previous VR-based active shooter training research. Liu et al. (2023) reported similar positive outcomes when comparing VR training to video-based methods, finding that higher interactivity levels significantly improved training effectiveness. Our training effectiveness scores ($M = 3.824$) are comparable to their reported improvements in participant

preparedness. Our finding of low pre-training anxiety ($M = 2.236$) also demonstrates improvement over traditional active shooter drill research. Zhe and Nickerson (2007) found that conventional intruder drills, while effective for knowledge acquisition, often induced stress and anxiety in participants. Our serious game approach appears to mitigate this anxiety response while maintaining perceived educational effectiveness. These findings suggest future opportunities to develop and expand serious VR game approaches that reduce anxiety while preserving educational effectiveness.

Study limitations and future directions

Given the severe limitation of only 3 VR participants versus 15 video participants, this study should be considered a proof-of-concept demonstration rather than a comprehensive evaluation. The inclusion of video participants provides preliminary insights into content structure but cannot substitute for actual VR experience data. The small overall sample size ($N = 18$) and, particularly, the small VR sample ($N = 3$) prevented statistical significance testing and definitive conclusions about VR-specific effects. COVID-19 restrictions at the time of the study necessitated the hybrid approach utilised in this study, limiting controlled comparisons. Technical constraints (3-DOF hardware, low-poly assets) may have reduced the immersion potential of VR. The prototype provides entry-level ALICE training, which may not capture the full complexity of emergency scenarios.

Future research should encompass a comprehensive evaluation using larger VR sample sizes with more immersive experiences using state-of-the-art 6-DOF VR hardware. Longitudinal retention assessments would also be a valuable future research direction. Additional measures for future work can include flow states during training, spatial memory of virtual environments, embodied learning transfer to real-world skills, and immersive empathy development through NPC interactions.

Conclusion

This research demonstrates that immersive experiences can be effective for entry-level ALICE-based active shooter training. Despite the limitations, we believe our mixed-format evaluation provides valuable insights into serious games and gamified VR training design for active shooter emergency preparedness, suggesting promising opportunities for future research and development. The evaluation revealed encouraging results, including low pre-training anxiety levels, moderate to high perceived training effectiveness, and positive user acceptance. The prototype contributes to the understanding that serious games can successfully balance educational content with engaging mechanics for sensitive training topics. With this prototype and preliminary evaluation, we hope to contribute to the advancement of VR-based emergency preparedness education.

About the authors

Daniel Zuniga-Vazquez is a PhD student in Systems and Industrial Engineering at the University of Arizona. His research interests include power systems reliability, wildfire, water-energy nexus, and biomass supply chain. He can be contacted at danielzunigav@arizona.edu

Ren Boz is an Assistant Professor in the School of Information (iSchool) at the University of Arizona. His research interests include game development, virtual/augmented reality, and human-computer interaction. He can be contacted at rboz@arizona.edu

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