

Methodology Article

Virtual Reality Training for Students and Responders in an Emergency Management Technology Program

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Abstract

Technology-enhanced simulation has emerged as an important instructional and operational tool for improving the effectiveness of emergency management education and training. Advanced simulation technologies, including virtual reality (VR), strengthen critical emergency management functions such as planning, forecasting, threat detection, situational awareness, security operations, and information sharing. These capabilities contribute to more informed decision-making and improved coordination among stakeholders, ultimately supporting the preservation of life and protection of property during disasters and other crisis events. As emergency incidents become increasingly complex—often involving natural hazards, technological failures, and human-caused threats—training methods must evolve to prepare future professionals with the skills required to operate in dynamic, high-risk environments. Research indicates that the integration of virtual reality exercises in emergency management training significantly enhances both tabletop exercises and traditional live simulations. Unlike conventional training approaches, VR-based simulations allow participants to engage repeatedly with realistic, immersive scenarios that closely replicate real-world disaster conditions. These environments enable learners to test strategies, evaluate response options, and observe the consequences of decisions in a controlled and risk-free setting. The repeatability and adaptability of VR scenarios allow instructors to modify conditions, introduce new variables, and reinforce learning outcomes across multiple training sessions. The purpose of this paper is to examine the role of virtual reality in simulation-based training for emergency management courses in higher education. Specifically, the paper explores how VR technology influences instructional practices, student learning outcomes, and the preparedness of emergency management professionals and decision-makers responsible for managing disaster response and recovery operations.

Keywords

Disasters, Emergency Management, Simulations, Virtual Reality

1. Introduction

Emergency Management organizes resources and responsibilities to prepare for, respond to, and recover from emergencies, whether natural, technological, or human-caused. As time progresses, Social Scientist, Quarentelli, predicted (1996

and 2001) the increase of disasters and the emergence of new and more impactful disasters. Such increases death and injury with greater economic impact [11]. As this prediction has

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Received: 10 February 2026; **Accepted:** 4 March 2026; **Published:** 20 April 2026



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come to fruition, the need for emergency management professionals unfolds. According to the U. S. Bureau of Labor Statistics, growth in this discipline will increase by 3% between 2024 and 2034 [16]. As the discipline grows, professionals must attain and maintain technological, computational, communications, policy, etc. With career opportunities being available in the workforce, research indicated that there are fewer than 12% of African American emergency management professionals. A 2022 project supported by the Federal Emergency Management Agency (FEMA) provided additional insight that promoting the need for emergency management workforce diversity and African American personnel [7]. To further promote and diversify this discipline, this proposed project will incorporate a multidisciplinary approach to develop emergency management professionals. Minority groups, such as African Americans with diverse academic backgrounds such as technology, will make tremendous strides in the Emergency Management Community. This can be vital as technology serves as a primary instrument for training and development of future and current Emergency Management professionals.

With technology such as virtual reality (VR) being at the vanguard of instruction and learning, the proposed project will incorporate VR simulation training for multidisciplinary programs at a Historically Black College/ University (HBCU). Virtual Reality simulations improve critical emergency management functions, including planning, forecasting, threat detection and security, information sharing, etc. This leads to better preservation of life and property. This provides a safe environment allowing participants to develop problem-solving proficiency, decision-making abilities, and confidence in addressing emergency and disaster situations [6, 7]. Developing these competencies evokes the need for sophisticated training through appropriate technology mediums. The scope and number of disasters have increased over the years, calling for more robust disaster preparedness training and plans. Virtual reality simulation technology has emerged as a critical tool for training specialized STEM program graduates to become highly proficient emergency responders and decision-makers in the Emergency Management enterprise.

Emergency Management is a growing discipline, and can be applied in any workforce arena when considering potential disasters that could occur. The Federal Emergency Management Agency (FEMA) defined Emergency Management as "the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters" [6]. This discipline has evolved into comprehensive academic programs across multiple STEM fields, with technology playing an increasingly vital role in VR and simulation-based training and response system development.

One training that has evolved over the years has been technology simulation training with VR. Researchers have indicated that simulations provide more synchronized learning practices to prepare responders for everyday life [9]. Researchers in 2022 indicated that simulations are significant in

training and preparing emergency professionals for severe natural disasters. Alshowair et al.'s study explored the benefits and challenges of utilizing VR in disaster preparedness. Researchers found that institutions should incorporate VR for training emergency and disaster management professionals [1, 8]. More importantly, universities can assist with training that will yield successful student learning outcomes for those seeking degrees or additional professional development in Emergency Management-related disciplines.

2. Why Use VR and Student Learning Outcomes

Virtual Reality (VR) has emerged as a transformative technology in education, offering immersive learning experiences that transcend the limitations of traditional teaching methods. This transformation promotes student engagement, leading to active learning. With active learning, students may engage in problem-solving activities, collaborative and critical thinking discussions, and other activities leading to a deeper comprehension of the subject matter. Real-world simulations help to create a memorable experience that students may transfer learned competencies from the classroom into actual situations. As educational institutions increasingly recognize VR's potential, this technology is revolutionizing how students engage with academic content, retain information, and develop critical competencies for the next level of education pursuit or career aspirations. These are a few examples of VR advantages in education [3, 4].

One of the most significant advantages of VR in education is its ability to dramatically increase student engagement and motivation. According to Brown, Genis, and Warnock, 82% of high school teachers find that VR provides extended reality learning experiences well designed and capable of delivering high-quality academic content to students [3]. Unlike passive learning through textbooks, VR places students directly inside three-dimensional environments where they can actively explore and interact with subject matter, as the study revealed. This study further revealed that students who find social interactions or verbal communication challenging, for example, may find it easier to work with educators in a VR setting. Such leads to increased learning retention.

The impressive characteristics of VR result in superior learning retention. VR training participants were found to be 4 times faster to train than in classroom settings and felt 3.75 times more emotionally connected to the material. By engaging multiple senses simultaneously and utilizing spatial memory, VR creates sensory-rich experiences that are significantly more memorable than text-based learning [6]. This multi-sensory approach enables students to retain concepts and details more clearly, particularly when dealing with complex, abstract subjects. A study from the American Consortium for Equity in Education [2] revealed that of 317 middle

school and high school students involved, the VR group increased retention by 35.2%, while the non-VR group increased retention by only 2.6%.

VR transforms abstract concepts into tangible experiences. In science education, students can explore the human body's internal systems, conduct virtual chemistry experiments with volatile substances, or travel through the solar system—all without leaving the classroom [8, 9]. In STEM fields, students can visualize geometric shapes in three dimensions, while engineering students can manipulate virtual models of structures before designing their own. These hands-on experiences bridge the gap between theoretical knowledge and provide a richer learning experience. This is also evident in Emergency Management, where Technology is the program concentration. Utilizing modern technology, such as VR, is instrumental in developing competencies through real-world scenarios. This is essential for current and aspiring Emergency Management professionals.

3. Technology Integration into Emergency Management Academic Programs

The use of virtual reality exercises in conjunction with tabletop exercises is considered a novel approach to disaster preparedness planning. Virtual reality simulation (VRS) technology offers a viable training alternative with its inherent features of reproducibility, just-in-time training, and repeatability. This research examines how the incorporation of advanced simulation technology by Emergency Management can enhance the infrastructure for emergency response execution, ultimately enabling communities to achieve greater resilience following disasters.

VR simulations can be pivotal in positively impacting the disaster response world. Simulation provides an imitative representation of disaster scenarios in which emergency and disaster management functions can be employed. This training mechanism may aid in efficient and effective emergency and disaster response [1]. Not only does technology simulation produce a more effective emergency and disaster response, but it also provides a safer environment for professionals, a greater probability of mitigating property damage, and an improved probability of saving lives [1, 5, 8]. A great example of VR disaster simulation is the Advanced Disaster Management Simulator.

3.1. Workforce Readiness Through Simulations

VR simulation platforms present real-world situations for training purposes, allowing trainees to gain confidence, practical experience, and decision-making skills needed to successfully resolve real-life incidents in a safe and repeatable environment. This Virtual reality training can further help

Emergency managers to get used to the new training environments to improve their roles. There are also mixed virtual reality simulations that train in the environment with real-world scenarios. With the new use of AI added to the virtual reality simulation, they were able to add multilevel and 3D environments, where in previous simulations they weren't able to have that built in [7, 8, 10]. The Environmental Tectonics Corporation indicated that simulation activities can prepare you for every situation that other training sessions might not have covered. Having as much training as possible can make a big difference when under extreme circumstances. This serves as a foundation for this HBCU's project, CREED.

CREED is the Community Resilience Enhancing Education on Disaster project funded by the U. S. Department of Transportation. CREED's vision is to equip communities with up-to-date skills for better disaster preparedness of natural and human-caused disasters, and to develop the disaster preparedness and emergency management workforce. Incorporating modern technology, such as VR simulations, will help students be trained and educated on preparedness for natural and human-imposed disasters. Moreover, the project will serve as a model for other Historically Black Colleges and Universities (HBCUs) in promoting community resilience and developing aspiring Emergency Management professionals. Additionally, VR simulation in emergency and disaster management and response provides training opportunities for planning, rehearsing, assessing, and increasing the competencies of emergency and disaster management professionals with the mission of preservation at the vanguard. Technology simulations complement the mission to save life and property. In this mission, VR simulation training helps to improve the effectiveness and efficiency of situations in which the impact of potential disasters may be mitigated. Such simulations can be provided in a virtual reality platform presenting real-world scenarios of disastrous incidents. In addition to enhancing the competencies of current emergency and disaster management professionals, VR simulations make the connection between formal education and training and live exercises. The platform used at one of Mississippi's HBCUs is the Advanced Disaster Management Simulator.

3.2. Virtual Reality in Emergency Management and Use in Academia

Environmental Tectonics Corporation (ETC) developed the Advanced Disaster Management Simulator (ADMS), which provides impromptu and open-ended virtual reality simulated disaster scenarios with outcomes based on the training participants' decisions [5]. ETC further contended that ADMS is a physics-based technology with built-in artificial intelligence to provide training participants with real-world experience in real time. The ADMS technology allows the training participant to engage and interact in remarkable decisions about actual disaster incidents. The Corporations emphasized that

ADMS provides a realistic 3D environment in which instructors can build many conceivable incidents and where training participants can experience real-time feedback from facilitators and leaders. This helps build knowledge, competencies, understanding, and confidence. ADMS, among other similar systems, is targeted to solve real-world problems surrounding natural and human-imposed disasters.

ADMS is an ideal teaching tool enabling participants to assess and improve preparedness plans through real emergency and disaster situations. Outcomes of those who participate in simulation training may include, but are not limited to the following:

- 1) Technology simulation will provide students with workforce experiences needed in Emergency Management and/or Disaster Preparedness so that they are prepared for Emergency Management and Disaster Response workforce and/or related academic degree programs; and
- 2) Simulation training will enhance emergency response decision-making to help minimize loss of life and property. Both of these, among other related systems, provide evidence of how technological innovation continues to improve approaches to preserving life and property in our world [5].

This research team has provided VR simulation demonstrations to students, Emergency Management professionals, educators, and community decision-makers. Throughout the process, participants have provided meaningful feedback.

4. Feedback from Faculty, Students, and Professionals

One of the project team members and Computer Science Professor, A. Tanner (personal communication, November 14, 2025) stated that “Virtual reality (VR) is useful in preparing students for careers in Emergency Management or related careers because VR can simulate critical infrastructure failures and disasters. It allows students to practice Incident Command roles and allows students to quickly assess risks, identify hazards, and coordinate response activities in real-time. In addition, students using VR tools enhance their situational awareness and build their confidence when encountering real-world emergencies. Resultantly, the use of VR tools provides necessary training and desired skills which help prepare them for careers in Emergency Management” [14].

From the student perspective, a student stated that “The training with the ADMS helped reinforce what I learned in my classes regarding disaster preparedness, providing a realistic and immersive experience that complemented the theoretical knowledge and made it easier to apply concepts in a practical setting. I feel that technology like the ADMS is vital for better preparing me for my career” [15].

Emergency Responders further indicated that “Training can equip first responders with the knowledge, skills, and abilities needed to achieve desired outcomes during times

of emergency or disaster. Being prepared for emergencies or disasters before an incident can greatly reduce the loss of life, property damage, and how fast an incident may be stabilized” [12, 13].

5. Conclusion

Virtual reality simulation provides reproducible, just-in-time training opportunities that enable comprehensive disaster scenario exercises. These platforms promote continuous improvement discussions regarding disaster preparedness and response while facilitating lessons learned integration. The World Health Organization [17] affirmed that simulation exercises validate and enhance preparedness and response plans, procedures, and systems across all hazard types and emergency management capabilities. VR marks a paradigm shift in education, offering in-depth, experiential learning that engages students in unparalleled ways. From improving retention rates and enabling virtual field trips to supporting diverse learning needs and providing career exploration opportunities, VR addresses many limitations of traditional teaching methods.

In unique and time disciplines, such as Emergency Management, VR is a crucial instrument in ongoing interactive training. VR training platforms address the critical need for scalable, cost-effective, and risk-free Emergency Management education that prepares aspiring and current professionals for real-world crisis scenarios while supporting community resilience-building efforts. This is very important in improving overall disaster preparation, decreasing response times, and preserving life and property.

Acknowledgments

This material is based upon work supported by the U.S. Department of Transportation-Maritime Transportation Research and Education Center under Grant Award Number-G634E85.

Abbreviations

VR Virtual Reality

Author Contributions

Jessica Murphy: Conceptualization, Formal Analysis, Funding Acquisition, Investigation, Project Administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing

Marlisa Scott: Resources, Writing – review & editing

Conflicts of Interest

We have no conflicts of interest to disclose.

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