

Beyond the Headset: A Multidomain Evaluation of CPR Readiness in Projection-Based Mixed Reality

Research Overview

A persistent gap exists between procedural CPR knowledge and the psychological readiness required to act in real emergencies (Hernández-Padilla et al., 2016; Oteir et al., 2021). Projection-based mixed-reality systems address this issue by surrounding learners with augmented stimuli while maintaining authentic haptic feedback and natural posture, without requiring any head-mounted display.

Purpose of Study

Despite accumulating evidence for immersive technologies in resuscitation education (Ricci et al., 2022; Baashar et al., 2022; Cheng et al., 2024; Li et al., 2025) and growing support for AR/MR-based CPR training specifically (Balian et al., 2019; Sungur et al., 2024), no published study has simultaneously evaluated this class of system across self-efficacy, attitudes, simulation design quality, technology acceptance, presence, and objective performance within a single cohort. This study, therefore, evaluated HiVE (Hybrid Immersive Virtual Environment), a six-sided projection-based mixed-reality system, in the context of CPR training across all six domains simultaneously.

Research Methods

The HiVE system combines spatial visual projection, three-dimensional audio, and multiple physical manikins installed with performance sensors. A quantitative pre-post design was employed with 121 healthcare students across 11 drill runs, each involving a 6-minute mass-casualty resuscitation scenario. Evaluation drew on an integrated six-domain framework: resuscitation self-efficacy (Basic Resuscitation Skills Self-Efficacy Scale [BRS-SES], 18 items, 0 to 100 scale; Hernández-Padilla et al., 2016); CPR-related attitudes (Oteir et al., 2021, 11 items, 1 to 5

Likert); simulation design quality (National League for Nursing Simulation Design Scale [NLN-SDS], 1 to 5; National League for Nursing, 2005); technology acceptance (Unified Theory of Acceptance and Use of Technology 2 [UTAUT2]-informed constructs, 1 to 5; Venkatesh et al., 2012); immersive presence (Igroup Presence Questionnaire [IPQ], 1 to 5; Schubert et al., 2001); and enjoyment and discomfort ratings. Notably, 97% of participants completed CPR training within the preceding 12 months and none had performed real-world CPR, meaning the gains observed here reflect confidence improvement on top of existing competence rather than baseline learning from scratch.

Results and Discussion

Mean self-efficacy increased from 76.3 to 82.2 out of 100 (+5.9 points), with 17 of the 18 BRS-SES items showing statistical significance ($p < 0.05$, paired t-test). The largest improvements spanned the full resuscitation sequence: assessing breathing and agonal respirations (+11.2), opening the airway (+10.1), alerting emergency services and initiating CPR (+9.2), performing CPR per current European Resuscitation Council (ERC) guidelines (+8.8), and minimising interruptions during compressions (+8.1). Overall attitude scores were most notably marked by two statistically significant item-level shifts: willingness to perform chest compressions for strangers (+0.23, $p < 0.05$) and attitudes toward learning CPR across cultural and religious contexts (+0.14, $p < 0.05$). The shift in bystander willingness is of particular practical relevance, given that hesitation to help during out-of-hospital cardiac arrest is a well-documented barrier to overall survival. Overall scores shifted from 3.47 to 3.56 out of 5 (+0.09).

The NLN-SDS yielded an overall mean of 4.16 out of 5, with debriefing-related items scoring highest (>4.30) and all problem-solving and clinical fidelity items exceeding 4.0. Technology acceptance averaged 4.10 out of 5, driven by strong performance expectancy (e.g., "Helps me learn CPR more effectively", 4.23) and hedonic motivation (4.21). IPQ presence averaged 3.80 out of 5 overall, consistent with

expected outcomes for non-HMD environments where meaningful spatial engagement rather than full perceptual immersion is the intended outcome. Eighty-nine percent of participants rated the experience positively on a 9-point enjoyment scale, and 73% reported no or minimal discomfort, though three participants reported motion-induced simulator sickness, specifically dizziness and nausea.

Taken together, across all six domains, HiVE produced improvements that were both statistically robust and practically meaningful. The breadth of self-efficacy gains, the shift in bystander willingness, the consistently strong ratings for simulation design and technology acceptance, and the high enjoyment figures alongside a largely comfortable experience together suggest that projection-based mixed-reality represents a viable and worthwhile approach to CPR training. These findings indicate that this model is transferable for simulation-based health professions education globally, particularly in contexts where HMD infrastructure is unavailable or impractical.

Keywords: mixed reality simulation; CPR training; self-efficacy; technology acceptance; healthcare education

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