

Abstract:

Screen-based simulation (SBS) and 3-dimensional virtual reality (3D VR) applied to pediatric emergency medicine (PEM) leverage digital technology to represent patients, populations, situations, and/or environments. SBS and 3D VR provide realistic, dynamic, safe opportunities for training and testing provider competency, systems-based practice, and environments. SBS engages the user to interact with a computer or mobile device screen to access and respond to content. Virtual reality adds the element of movement and/or allows manipulation of the SBS. 3D VR uses head-mounted ocular technology to create an environment in which the user is immersed as an active participant. SBS and 3D VR types include virtual patients, virtual worlds, screen-based haptic trainers, and resource management simulators. Advantages of SBS and 3D VR simulation over mannequin-based simulation are that it is infinitely replicable; can be distributed widely to devices simultaneously; is portable; enables tracking, storing, and analysis of massive amounts of usage and performance data; and does not require the presence of a live instructor. Disadvantages include cost, technical problems, and lower fidelity. We provide examples of types of SBS and 3D VR relevant to PEM that are currently available and in development; PEM-specific uses of SBS and 3D VR for training and testing, as well as uses for research to determine best practices for acquiring and retaining PEM knowledge and skills; and strategies for integrating SBS and 3D VR into training and PEM practice.

Screen-Based Simulation and Virtual Reality for Pediatric Emergency Medicine

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In this era of medical care with intense focus on high reliability and safety, simulation has become the standard for safe learning to improve quality and patient safety. Simulation is particularly valuable for pediatric emergency medicine (PEM) given the broad scope of practice; the rare, high-stakes critical conditions and events; and the need to allocate resources based on circumstance and volume. High-fidelity mannequin-based simulation (MBS) provides safe and effective opportunities for training and for testing provider competency, systems-based practice, and environments. Unfortunately, because of the high cost of equipment, human resources, and physical space, it is not available to the vast majority of health care providers worldwide. Furthermore, if available, MBS is often limited to infrequent opportunities that require preparation, personnel, and scheduling, making it difficult to run proximate to the time that the knowledge and skills are needed. Screen-based simulation (SBS) and 3-dimensional virtual reality (3D VR) simulation offer relatively low cost, on-demand, user-driven access and are rapidly evolving and becoming widely available. This article describes and provides PEM-relevant examples of SBS and 3D VR, describes types of SBS and 3D VR and their advantages and disadvantages for PEM, and offers examples for use and integration of SBS and 3D VR into PEM training and practice.

Keywords:

screen-based simulation; virtual reality; haptic; virtual patient; virtual world

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1522-8401

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SBS AND VR DEFINED

Screen-based simulation in PEM is a form of simulation in which a clinical scenario with 1 or more patients is presented through a digital screen surface.¹ The environment may or may not be a feature of SBS. Current technologies including flat-screen desktop and laptop computers, tablets, iPads, and smart phones, along with the Internet, have created a ready-made infrastructure for SBS. SBS commonly uses static imagery, text, audio, or videos. VR-enhanced SBS adds the illusion of what is intended to be a higher-fidelity, dynamic 3D patient or patient care environment. This enables cues from simulated patients, other providers, and the environment itself. Interactions with the SBS and VR come from within the environment as an avatar or by using off-screen hand movements or haptic devices to perform manipulations and procedures. Screen-based VR can be projected onto larger even life-size screens to maximize the relationship between user and avatar.

Three-dimensional VR has pushed the boundaries of fidelity and almost always uses 3D avatars that are now very common in

both serious and entertainment games, including even computer-generated movies. Newer technologies such as goggle-based headsets that allow for immersive VR move VR simulation beyond the confines of the flat screen within SBS. Goggle-based technologies that permit the user to isolate oneself into the VR, such as *Oculus Rift* (Oculus VR, LLC, Menlo Park, CA), *HTC Vive* (HTC Corporation, Xindian City, Taipei), *Gear VR* (Samsung, Ridgefield Park, NJ), and *Google Cardboard* (Google, Mountain View, CA), allowing for further uses of VR, are still being explored in the health care simulation setting.

Although SBS and 3D VR are wildly different technologically, they are largely similar from an educational conceptual framework point of view. SBS and 3D VR provide an experiential learning environment that embodies Knowles' principles of adult learning that recognize self-directedness of adult learners and their preference for goal-oriented learning with real-world applicability.² SBS and 3D VR also allow for on-demand access to concise, multimedia dynamic content. It embeds tasks to be performed by the user, allows users to work at their own pace, and provides immediate feedback. As with other forms of simulation, SBS and 3D VR provide the learner with a cognitively realistic and experiential setting without danger of actual patient or population harm. Furthermore, unlike MBS, SBS and 3D VR can be available on-demand and are well suited for learning and testing of cognitive and psychomotor tasks by a wide audience of individuals and groups separated by space and time.

TYPES OF SBS AND 3D VR

Within SBS, there are different types, each with unique features and capabilities for emphasizing knowledge, data gathering, cognitive thinking, procedural skills, communication, teamwork, and interaction with patients and families for situations relevant to PEM.

Virtual Patients

Virtual patients (VPs) use a virtual rendering of patients to replicate a provider-patient encounter, often to teach and assess knowledge, diagnostic skills, and management. Patients may be static or interactive. VR adds 3D representation of the patient in the form of an avatar. The more robust VP simulators allow for subtle physical examination findings and even naturalistic conversations. For PEM, VPs are particularly useful for acquiring and maintaining competency for the evaluation and management of patients with rare and/or high-stakes conditions that are difficult to obtain in a real-patient clinical setting. Resuscitation simulations such as those used for pediatric advanced life support and advanced cardiac life support training are a popular version of VPs used for PEM.^{3,4} VPs also provide an opportunity to provide exposure to common medical conditions as well. The Committee for Student Education in Pediatrics has coordinated pediatric cases that are designed more for general pediatrics, although with applicability to PEM.⁵ Image and case banks allow for the deliberate practice with feedback on large numbers of virtual cases.⁶ VPs as an

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