Guideline for scenario writing and AR/VR development

Enhancing Practices and Strengthening Core Competencies In Disaster Nursing through the Learning HUB (ECoDN-HUB)

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Content

Introduction Virtual Reality (VR)

Virtual Reality (VR) is a technology that enables users to immerse themselves in simulated environments created through computer graphics. Its main goal is to induce a sense of presence in a completely different, so-called virtual space. VR finds applications in various fields, including gaming, education, medicine, architecture, and training (Jerald, 2015).

Main Characteristics of Virtual Reality

1. Interactivity: Users can manipulate objects and influence the environment using devices such as VR headsets and controllers (Burdea & Coiffet, 2003).
2. Immersive Experience: VR provides realistic perceptions that fully engage the user visually, auditorily, and tactilely.
3. Simulation: Technology allows for the simulation of situations that would otherwise be dangerous or inaccessible in the real world.
4. Sensory Stimulation: In addition to visual experience, VR often includes sound and haptic feedback, enhancing realism and immersion (Slater & Sanchez-Vives, 2016).

The Importance of VR in Education and Simulation

Virtual reality offers a safe and controlled environment for learning, which is crucial in areas requiring precision and critical decision-making, such as medicine. Students can practice skills without real-world risks, enabling more confident learning (Makransky & Lilleholt, 2018).

Another advantage is the ability to repeat training scenarios. Unlike traditional methods that often allow only one-time practice, VR lets students revisit simulations multiple times, ensuring mastery of the subject matter. Active involvement through interactive experiences enhances motivation and memory retention (Radianti et al., 2020).

VR also improves retention through experiential learning. Learners remember information better when they can 'touch' or experience it, rather than just read or watch. Visualizing 3D scenarios helps understand complex concepts and apply them in practice (Dede, 2009).

One of VR’s key benefits is immediate feedback. For example, while practicing medical procedures, the system can instantly analyze a student's performance and offer suggestions. This immediate feedback speeds up the learning process and improves skill development (Johnsen et al., 2016).

Finally, VR supports various learning styles—visual, auditory, and kinesthetic, making it suitable for a wide range of learners and enhancing inclusive education (Merchant et al., 2014).

VR Script

A VR scenario is a detailed plan that describes how the experience will be structured and executed within the virtual environment.

The virtual reality scenario is critical to the success of any VR project, as it determines how the experience will be structured and what interactions will be available. A good scenario not only increases user engagement rates but also improves learning efficiency and encourages repeat use, which can be invaluable in education, training and entertainment. The key to a successful VR experience is therefore a well thought out scenario that takes into account all aspects of user engagement within the virtual world.

Structure of VR script

- Initial briefing and instructions – Providing clear objectives and instructions is key for effective VR engagement (Dede, 2025)
- Interactive decision-making moments – Integrating decision points allows users to influence the course of the simulation (Murray, 2021)
- Realistic visual and audio elements – The use of authentic visuals and sound enhances presence (McMahan, 2024)
- User performance evaluation – Feedback systems allow users to track their progress (Bautista & Lin, 2023)

Key Elements of VR Scriptwriting

- Immersive storytelling and interactivity – Combining narrative with interaction enhances user engagement (Ryan, 2021)
- Branching storyline structure – Offers users multiple narrative paths (Murray, 2021)
- Use of 3D space and motion interaction – Enhances the realism of the simulation (Choi & Baek, 2022)
- Adapting difficulty levels to users – Dynamically adjusts challenge based on user abilities (Bautista & Lin, 2023)

Practical Script Development

- Selecting the simulation topic – Relevance and realism are crucial (Nguyen, 2020)
- Designing a storyboard – Helps organize and execute the scenario (Cummings, 2020)
- Identifying key decision points – Essential for simulation interactivity (Murray, 2021)

- Testing and iterating the script – Ensures quality and effectiveness (Bautista & Lin, 2023)

VR Technologies and Tools

- Hardware and software – Choosing the right devices and development tools (Vince, 2023)
- Importing 3D models – Realistic models increase credibility (Cummings, 2020)
- Programming interactions – Implemented via C# or Blueprints (Cummings, 2020)

Key Insights for VR Development

1. User-Centered Scenario Design

Scenarios should be designed based on cognitive load theory and situated learning principles, ensuring learners engage meaningfully with clinical content (Makransky & Lilleholt, 2018). Understanding learner profiles allows for the alignment of complexity with their training level (Radianti et al., 2020).

2. Technical Compatibility and Scalability

Development should prioritize platforms that allow cross-device deployment and future extensibility. Modular design frameworks help maintain flexibility as technological needs evolve (Smith & Duggan, 2020).

3. Integration of Realistic Medical Protocols

All interactions should align with current evidence-based guidelines. Involving clinical experts during scenario writing ensures accuracy and credibility, a key component in medical VR (Nguyen, 2020).

4. Effective Feedback Mechanisms

Feedback should be immediate and contextual, including both performance-based cues and educational debriefs (Johnsen et al., 2016; Bautista & Lin, 2023). Reflection supports deeper knowledge consolidation and clinical judgment.

5. Use of Branching Narratives

Branching paths allow users to face consequences based on their decisions, enhancing realism and agency (Murray, 2021). This technique has been shown to improve problem-solving and engagement in VR environments (Ryan, 2021).

6. Realism and Sensory Immersion

High-fidelity visuals, spatial audio, and haptic feedback can significantly improve immersion and knowledge retention (Slater & Sanchez-Vives, 2016; McMahan, 2024). Realistic physiological responses in patients—like bleeding or shock—should be used to simulate time pressure and stress.

7.Continuous Testing and Improvement

Scenario usability, technical stability, and educational value should be evaluated through iterative testing with end users (Freina & Ott, 2015). Feedback loops support continuous enhancement of both technical and pedagogical design (Radianti et al., 2020).

VR USER INITIATION AND GUIDANCE

To ensure a positive and effective learning experience in virtual reality, each VR scenario should begin with a brief onboarding and orientation module. This phase introduces the user to the VR environment, interaction mechanics, and scenario expectations—crucial steps for reducing anxiety, minimizing cognitive overload, and preventing early disengagement.

Purpose of Onboarding

Virtual environments can be disorienting or overwhelming for first-time users. An onboarding module provides a safe space to:

- Acclimate to the controls (e.g., grabbing objects, moving, looking around).
- Understand interaction cues (e.g., tool icons, hand prompts, gaze selection).
- Familiarize themselves with feedback systems (e.g., vibration, color changes, voice prompts).

By reducing initial confusion, onboarding frees cognitive resources for actual learning tasks (Makransky & Lilleholt, 2018).

Recommended Features

A well-structured onboarding experience should include:

1. Simple Interaction Tutorial: Users practice grabbing, dropping, or activating items in a low-pressure setting (e.g., a training room or virtual lab).
2. Mobility Orientation**:** Introduce movement systems—teleportation, joystick navigation, or gaze walking—depending on the platform.
3. Interface Elements: Explain any HUD (heads-up display), icons, timers, or health indicators. Highlight critical symbols (e.g., bleeding status, task reminders).

4. Practice Task (Optional): Provide a sandbox or micro-task (e.g., pick up and apply gloves, speak to a virtual character) to reinforce skills without consequence.
5. Skippable Option: Allow experienced users to skip onboarding but always make it available again from the main menu.
6. Comfort and Accessibility Check: Let users adjust settings: text size, subtitles, motion sensitivity (to reduce simulator sickness), and audio levels (Dennison & D'Zmura, 2020).

Benefits

Research shows that onboarding modules:

- Reduce simulator sickness and disorientation (Dennison & D'Zmura, 2020).
- Increase confidence and immersion (Slater & Sanchez-Vives, 2016).
- Improve task performance in VR simulations—especially for novices (Makransky & Lilleholt, 2018).

Integration into the Scenario Flow

The onboarding module should be a mandatory first-time step but separated from the main scenario logic. It should feel like a "training room" or "briefing area" where users are introduced by a virtual assistant, voiceover, or UI prompts.

Testing VR Simulations

- User testing and feedback – Helps improve the simulation (Bautista & Lin, 2023)
- Minimizing motion sickness – Optimizing movement reduces discomfort (Dennison & D'Zmura, 2020)
- Improving UX – Intuitive controls increase satisfaction (Vince, 2023)
- Adjusting the script – Error analysis drives iteration (Bautista & Lin, 2023)

Cross-Platform Design Recommendations

Cross-platform development in the realm of virtual reality (VR) is paramount to guaranteeing that VR simulations are both inclusive and accessible, while simultaneously ensuring scalability within a variety of educational and institutional contexts. This section delineates comprehensive guidance on optimal practices for cross-platform VR design.

1. Platform-Agnostic Development Frameworks

In order to enhance accessibility and mitigate the necessity for redevelopment:

- Employ the Unity XR Interaction Toolkit or Unreal Engine in conjunction with OpenXR to facilitate support across Oculus, HTC Vive, Windows Mixed Reality, and WebXR platforms.
- Refrain from utilizing proprietary SDKs unless the objective is to target a specific platform.
- Leverage WebXR to enable browser-based access, thereby permitting deployment without the prerequisite of high-end VR hardware.

2. Performance Optimization for Low-End Devices

Performance consistency across diverse devices is imperative:

- Maintain low texture sizes and polygon counts to ensure seamless rendering on mobile headsets.
- Implement occlusion culling, baked lighting, and Level of Detail (LOD) techniques to diminish computational demands.
- Simplify physics simulations by reducing reliance on real-time rigid body dynamics and cloth/hair physics (Vince, 2023).

3. Input and Interaction Flexibility

Users of VR may interact through a myriad of input modalities:

- Incorporate gaze-based selection, hand tracking, controller input, and voice commands.
- Design interaction zones with expansive hitboxes to account for varying tracking accuracies.
- Ensure that all interactive components are accessible through multiple input modalities to promote accessibility (Slater & Sanchez-Vives, 2016).

4. Modular and Scalable Architecture

Facilitate adaptability and maintainability:

- Decompose the VR scenario into modular components (e.g., environment loader, interaction handler, user interface layer).
- Promote updates and scalability by sustaining loosely coupled scripts and scene management systems.

5. Session Design and Cognitive Load

VR sessions must be designed with consideration for user welfare and attention spans:

- Structure modules in segments of 3–7 minutes with well-defined learning objectives. Integrate principles of cognitive load theory by constraining simultaneous stimuli (audio, text, motion).

- Provide opportunities for optional breaks and progress checkpoints during extended scenarios (Makransky & Lilleholt, 2018).

6. Inclusive and Accessible Design

Ensure that VR content is usable by a diverse audience:

- Offer customization options including text scaling, audio level adjustments, subtitle toggling, and color contrast themes.
- Implement strategies for motion sickness mitigation: employing teleportation in lieu of smooth locomotion, applying vignette effects, and maintaining stable horizon lines.
- Facilitate audio cues and narration for users with visual impairments (Merchant et al., 2014).

Benefits and Challenges of VR Training

- Realistic and safe education - Virtual Reality (VR) enables the simulation of real-life situations in a safe environment, which is especially valuable in fields such as medicine, aviation, or industrial operations. It allows students and workers to experience scenarios that would otherwise be dangerous or difficult to access (Jerald, 2015)
- Enhances retention and practical skills - Research shows that VR training supports better information retention and the development of practical skills through interactive user engagement (Smith & Duggan, 2020). Users are not just passive recipients of information, but actively participate in simulations, increasing learning efficiency
- Technological barriers and costs - One of the main challenges is the high cost of required hardware and software. Additionally, compatibility issues and technical problems during use must be considered (Radianti et al., 2020)
- Need for instructor training - Effective implementation of VR also requires training for instructors who will work with the technology. Without sufficient preparation, the potential of VR might be misused or even demotivate users (Freina & Ott, 2015)

VR DEVELOPMENT WORKFLOW

A meticulously organized workflow is pivotal for the development of efficacious, pedagogically sound, and technically proficient virtual reality experiences. Presented below is a comprehensive dissection of the virtual reality development pipeline, accompanied by actionable steps pertinent to each distinct phase.

Phase 1: Define Pedagogical Objectives

- Articulate fundamental learning outcomes predicated on curricular or training requisites.
- Specify both technical competencies (e.g., CPR techniques) and interpersonal skills (e.g., decision-making in high-pressure situations).
- Ensure alignment with established educational frameworks, such as Bloom's Taxonomy (Makransky & Lilleholt, 2018).

Phase 2: Scenario Scriptwriting

- Select between linear and branching narrative structures.
- Integrate authentic dialogue, interaction prompts, and outcomes contingent upon user decisions.
- Incorporate emotional and contextual narrative elements to enhance immersion (Murray, 2021).

Phase 3: Environment and Character Design

- Construct precise three-dimensional environments pertinent to the scenario (e.g., hospital, urban street).
- Employ real-world references and architectural blueprints to augment realism.
- Develop a diverse array of expressive virtual characters equipped with animation rigging to convey emotion and feedback (Jerald, 2015).

Phase 4: Interaction Design and Implementation

- Articulate the modalities through which users will engage with the scenario, including object manipulation, menu navigation, and dialogue systems.
- Employ input mapping frameworks to generalize interactions across varying devices.
- Incorporate immediate system feedback (visual, auditory, haptic) in response to user actions (Choi & Baek, 2022).

Phase 5: Feedback and Assessment Mechanisms

- Integrate both formative and summative feedback systems: Real-time prompts: "Insufficient pressure applied. Please attempt again."
- Post-scenario evaluations: scorecards and performance timelines.
- Consider adaptive feedback systems informed by user behavior (Johnsen et al., 2016).

Phase 6: Internal Quality Assurance Testing

- Implement iterative testing cycles: Conduct alpha testing to assess core mechanics and interactions.

- Engage in beta testing to evaluate narrative coherence, performance metrics, and bug identification.
- Utilize debug logs, screen recordings, and in-simulation analytic tools.

Phase 7: User Testing and Evaluation

- Recruit participants representative of the target demographic (e.g., nursing students).
- Gather both qualitative and quantitative data: Usability metrics (ease of interaction, navigational efficiency) Educational effectiveness (knowledge retention, skill enhancement) Engagement levels (emotional immersion, perceived realism) (Freina & Ott, 2015).

Phase 8: Deployment and Continuous Improvement

- Deploy the simulation within the designated educational environment.
- Provide training for facilitators on the utilization of the virtual reality experience and the interpretation of results.
- Monitor usage analytics, gather continuous feedback, and implement iterative improvements as necessary (Radianti et al., 2020).

Conclusion and Recommendations

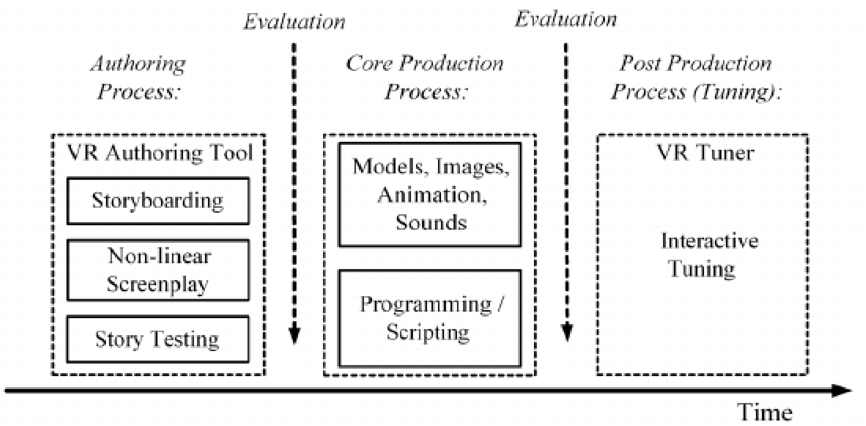
- VR is a powerful tool for learning and training - Virtual Reality represents a revolutionary tool for education and professional training. Its ability to simulate realistic scenarios supports deeper understanding and more effective skill acquisition (Radianti et al., 2020)
- The quality of scripts and realistic interactions is crucial - The key to successful VR training lies in the quality of scenarios and the level of interactivity. Realistic scripts allow users to immerse themselves in the environment and respond authentically, enhancing the learning effect (Smith & Duggan, 2020)
- Testing and feedback are essential - Regular testing of VR program effectiveness and user feedback collection help improve both content and delivery methods (Freina & Ott, 2015). Monitoring progress allows training to be tailored to individual needs
- The future: AI and haptic technologies - The future of VR lies in integration with Artificial Intelligence (AI) and haptic technologies, enabling content personalization and physical feedback – further bridging the gap between virtual experience and reality (Jerald, 2015)

Algorithm for Creating a VR Scenario

Overview of the process for designing an educational VR scenario

1. Define educational objectives (e.g., proper bleeding control techniques) – Setting clear goals ensures that the VR experience aligns with learning outcomes and skills development (Radianti et al., 2020)
2. Identify the target audience (medical staff, laypeople, students) – Knowing the users allows customization of difficulty level and instructional methods (Freina & Ott, 2015)
3. Design a realistic environment (e.g., street, home, hospital) – A familiar and authentic environment enhances immersion and contextual learning (Jerald, 2015)
4. Choose a VR platform – The selection of hardware and software should consider accessibility, scalability, and technical capacity (Smith & Duggan, 2020)
5. Define interaction mechanisms (controllers, voice commands, gestures) – Interaction design is key for user engagement and realism (Jerald, 2015)
6. Determine the level of graphical detail – Visual fidelity affects user immersion, cognitive load, and learning outcomes (Radianti et al., 2020)

Fig. 1 The proposed production process of a VR scenario



Wages, R., Grützmacher, B., Conrad, S. (2004). Learning from the Movie Industry: Adapting Production Processes for Storytelling in VR. In: Göbel, S., et al. Technologies for Interactive Digital Storytelling and Entertainment. TIDSE 2004. Lecture Notes in Computer Science, vol 3105. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-27797-2_16

Scenario Design

- Introductory instructions – The user is introduced to the scenario with a tutorial that explains tasks and how to use controls, ensuring they are comfortable with the interaction mechanics (Freina & Ott, 2015)
- Situation simulation – A virtual character appears with a bleeding injury. The wound features realistic animation to simulate an emergency situation, providing an immersive and engaging experience (Jerald, 2015)
- Interaction options – The user is given multiple choices to respond to the situation, such as applying pressure to the wound, using a bandage, or applying a tourniquet. These choices influence the scenario's outcome and reflect decision-making skills (Smith & Duggan, 2020)

- Evaluation – The system evaluates the user's actions, providing immediate feedback on correctness, efficiency, and adherence to recommended medical procedures (Radianti et al., 2020)

Scenario Objectives

The scenario should clearly define why it is being created and what its main objectives are. These objectives should include and clearly define both soft and hard skills. Soft and hard skills are terms used to differentiate between different types of abilities that individuals can possess in professional life. Each type of skill is a key component of successful performance in various fields.

HARD Skills

Skill is the ability to use one's knowledge effectively and promptly in execution or performance. Hard skills are technical abilities and expertise specific to certain tasks and situations. They relate to technical or practical skills, as opposed to soft skills, which relate to interpersonal skills. These skills are essential for providing quality and safe patient care. According to the American Nurses Association (2015), technical skills are crucial for effective implementation of therapeutic interventions and monitoring of patients' condition.

Hard skills are measurable and are usually acquired through formal education, training, or practical experience. Hard skills are necessary for specific tasks and must be well mastered, especially in an environment where quick and accurate responses are required. They are necessary for specific tasks in an industry that requires specific expertise and skills (Lamri & Lubart, 2023).

HARD Skills - e.g.

- Use of tourniquet, bandage
- Perform a quality heart massage
- Securing the airway
- Providing effective artificial respiration
- Etc.

Soft skills

SOFT Skills are social and emotional competencies related to interaction with others. Soft skills are a dynamic combination of cognitive, metacognitive, interpersonal, intellectual and practical abilities, as well as ethical values. These skills are not as easily measurable as hard skills and often include personality traits and behavioral patterns that influence the way individuals communicate and cooperate with others. They are the basis of critical thinking. They can be learned through appropriate and systematic training (Widad & Abdellah, 2022).

The basis of non-technical skills in acute medicine and crisis situations consists of four areas, which are connected by the main thing - communication. These areas include teamwork, team leadership itself, situational awareness, decision-making and the distribution of tasks among other team members (Peřan & Kubalová, 2017).

One of the main non-technical skills within teamwork is communication. Communication within the team should always be calm, assertive, and team members should support each other. Communication should be clear, distinct, with the aim of closing the communication loop (Peřan & Kubalová, 2017). For example: A specific instruction must be formulated clearly: "Peter, give 1 mg of adrenaline i.v.," not "Someone give adrenaline…" The team member should then confirm receipt of the information: "I understand, I am giving 1 mg of adrenaline i.v.," and then inform about the fulfillment: "1 mg of adrenaline i.v. given." This is an example of a perfectly closed communication loop.

Situational awareness primarily concerns the collection of information, its understanding and, based on that, predicting where the situation will develop. Maintaining situational awareness is crucial for moving towards the right goal. It is necessary to identify the situation and get it under control. Furthermore, to predict how the situation will develop, analyze the available information and, based on this, plan and implement steps towards resolving the situation (Peřan & Kubalová, 2017). An example of situational awareness is that the team leader should have an overview of how many defibrillation shocks have been performed during CPR and be ready to issue an instruction for another shock at the right time.

One of the other non-technical skills is the ability to make decisions and make the right decisions. However, making the right decisions cannot be done without perfect situational awareness. These two skills therefore go hand in hand. The team leader can consult with the team in certain situations (Peřan & Kubalová, 2017). For example: The patient is very aggressive; I suggest this procedure. Do you agree?

Another non-technical skill is the distribution of tasks. Most crisis situations require the coordination of many tasks that need to be done in a short time interval and with the greatest possible accuracy. The task of the team leader is to oversee the even distribution of the load among all team members and the prioritization of task performance. With proper planning and preparation of individual activities, we have a greater chance of adhering to all standards of care and recommended procedures. It is a mistake to issue many instructions at once. In most cases, some of the quickly issued instructions are forgotten. Tasks should be distributed according to priorities and to specific individuals (Peřan & Kubalová, 2017).

SOFT Skills – e.g.

- Resistance to stress
- Team leadership

- Teamwork in simulation – if VR is multiplayer, cooperation with other participants is necessary
- Effective communication
- Ability to close the communication loop
- Decision making process
- Allocation of tasks among team members
- Assessing the situation and making decisions – recognizing critical bleeding and choosing the right course of action

Description of the situation

The description of a situation in a VR scenario is a critical component that shapes the user's experience and engagement within the immersive environment. It sets the context for the actions the user will undertake, guiding them through the narrative and influencing their emotional and cognitive responses. A well-crafted situation description serves multiple purposes, including establishing a sense of realism, conveying urgency, and providing the necessary background for the user to effectively navigate the scenario.

The description of a situation in a VR scenario is a comprehensive and multifaceted element that encompasses the setting, character introductions, contextual background, challenges, and emotional tone.

The first step in describing a situation is to establish the setting. This includes geographic location, time period, and environmental conditions. Setting the scene effectively immerses users in the environment, allowing them to visualize their surroundings and feel as though they are truly present within the scenario. A vivid and detailed description of this environment can enhance users' emotional engagement, making them more invested in the unfolding events.

Next, the situation description should introduce the characters involved in the scenario. This includes key details about the characters' roles, backgrounds, and emotional states. In a VR medical training scenario, for instance, the primary character could be a patient with a visible injury, depicting realistic physical symptoms and displaying a range of emotions, from panic to pain. The presence of supporting characters, like nurses or doctors, can further enrich the narrative by providing context on the teamwork required in emergency situations.

Providing contextual background is essential for helping users understand the circumstances leading to the scenario. This can include previous events, the nature of the problem at hand, and potential challenges that may arise. For instance, a scenario might open with a brief synopsis explaining that the user is stepping into the shoes of a first responder who has arrived at the scene of a car accident. The description might highlight that several victims require immediate attention, and that time is of the essence.

Context not only enhances the narrative but also better prepares users for the decisions they must make. A well-defined background ensures that users comprehend the significance of their actions within the overarching narrative, motivating them to engage actively and responsibly.

For example:

In front of the user lies a young man who is bleeding profusely from a deep wound on his forearm. His clothes are stained with blood and his breathing is fast and irregular. He looks up at the user with a frightened expression and says in a quiet voice: "Help me..." Next to him on the ground lies broken glass, probably the cause of his injuries.

The user must make a quick decision – assess the condition of the injured person, stop the bleeding and ensure that the patient is safe before the ambulance arrives. In an interactive environment, they can choose various tools from the first aid kit, communicate with the patient and instruct surrounding witnesses to call for help.

As soon as he begins to administer first aid, the scenario reacts dynamically – if he presses the bandage correctly on the wound, the bleeding slows down, but if he hesitates or uses the wrong technique, the patient begins to show signs of shock, which complicates the situation.

The aim of this scenario is to simulate realistic first aid training under pressure, where the player learns to react correctly in a crisis situation.

Description of the environment

It describes the environment in which the action takes place, including visual and audio cues that create the overall atmosphere. Contextualising the scenario is important to engage users and ensure that the environment is relevant to the objective.

For example:

The user finds himself on the street next to an injured person lying on the ground. The surrounding environment is busy – you can hear muffled voices of people, the distant sound of sirens and the hustle and bustle of the city. The surrounding houses are damaged by the earthquake Curious passers-by are slowly gathering around.

Tools and objects

Write what tools are needed – according to the textbook, standard, add pictures – e.g.

Interaction – what should the participant do?

For example:

The user must make a quick decision – assess the condition of the injured person (physiological functions, general condition), stop the bleeding and ensure that the patient is safe before the ambulance arrives. In an interactive environment, they can choose various tools from the first aid kit, communicate with the patient and instruct surrounding witnesses to call for help.
As soon as he starts to perform first aid, the scenario reacts dynamically – if he applies the bandage correctly to the wound, the bleeding slows down, but if he hesitates or uses the wrong technique, the patient begins to show signs of shock, which complicates the situation.

Development and Implementation

- Creation of 3D models for environments and characters:
  Designing and modeling realistic 3D environments tailored to the educational context
  Creating detailed character models with a focus on anatomical accuracy and realistic movements
- Programming interactions and physical simulations (e.g., bleeding behavior based on incorrect actions):
  Developing interaction systems that allow users to manipulate objects and characters
  Implementing physical simulations, such as realistic bleeding in response to incorrect medical procedures
- Integration of AI for dynamic response to user actions:
  Developing artificial intelligence that reacts to user actions in real time
  Setting up dynamic scenarios where errors or correct actions influence the course of the simulation

Testing and Optimization

- Internal testing by developers:
  Conducting ongoing functionality testing within the development team
  Identifying and fixing technical issues before broader user testing

- User testing with target audience:
  Organizing testing sessions with real users from the target audience (e.g., medical students)
  Gathering feedback on usability, realism, and educational value
- Refining scenario and interactions based on feedback:
  Adjusting scenarios and interactions according to tester feedback
  Improving controls, visual quality, and AI reactions to maximize learning effectiveness

Deployment and Effectiveness Evaluation

- Deployment in educational institutions:
  Implementing the simulation in schools, universities, or training centers
  Providing necessary technical support and staff training
- Data collection on user success rates:

Monitoring and recording user performance during simulation use
Analyzing success rates and error patterns

- Interactive improvements based on performance analysis:
  Identifying learning weak points based on collected data
  Updating scenarios and AI systems to better support skill acquisition

HOW DETAILED SCENARIO SHOULD BE

The virtual reality scenario should be thoroughly developed to simulate a real emergency situation as accurately as possible. The total length of the scenario should range between 3-7 minutes per case. Shorter scenarios (1-2 minutes) can be used to practice specific skills. The length should be adjusted according to the target group (children, adults, healthcare professionals). At the same time, it should cover as many details as possible, e.g. skin color - cyanosis, color of bleeding, sound phenomena - difficulty breathing.

Example of errors that can be in a virtual scenario

Errors/Incorrect Procedure in VR Scenario	Consequence	How the VR Scenario Should Respond
Checking breathing only visually for 3 seconds	Breathing should be checked for 10 seconds using sight, hearing, and touch – otherwise, shallow breathing may be missed	Show correct technique (sight, hearing, touch), play 10-second timer, provide visual and voice guidance
Skipping the emergency call	Without calling EMS, professional help may be missing – endangering the patient's life	Scenario should include prompting to call 112/911, simulate call, and include follow-up questions
Incorrect hand placement during chest compressions	Compressing outside the chest center is ineffective and may cause injury	Show anatomy, highlight correct area, and provide visual feedback like "move hands"
Incorrect compression rate (e.g., 60/min)	Slow compressions are ineffective – insufficient oxygen to the brain	Use metronome or music at 100–120 bpm, provide visual tempo indicator
Ignoring rescuer safety	The rescuer may get injured – not assessing risk endangers more lives	Simulation should force safety check before approach – otherwise, scenario restarts

TEMPLATE LINEAR SCENARIO

Scenario objectives: *Describe what goals are to be achieved e.g. teach the user how to properly stop massive bleeding*
HARD Skills: Describe what hard skills a person is supposed to learn through a VR situation
SOFT Skill: Describe what soft skills a person is supposed to learn through a VR situation
Description of the situation: Describe the situation in detail so that the designer can make it, approach it as if you were describing a story to someone. Describe in detail what steps the user will take to achieve the goal
Description of the environment: Describe the environment in which the story takes place, e.g. a street, a forest, a broken-down house, what it looks like, what is happening there
Interaction – what should the participant do Describe what steps the participant should take and when is the situation finished
Tools and objects: Write down all the tools that the user has available in the VR situation and add an image so that the designer knows what to prepare, e.g. bandage, tourniquet, defibrillator, syringe. Draw from standards or professional sources

What mistakes can happen? What will be their impact?

Error	Consequence

LINEAR SCENARIO FOR VR SIMULATION OF FIRST AID IN HEAVY BLEEDING

In a linear scenario, the user proceeds through predetermined steps without the possibility of branching the plot. This means that they must follow precisely defined steps that lead to successful bleeding arrest

SCENARIO OBJECTIVES

HARD Skills

1. Usage of a tourniquet, bandage

SOFT Skill

1. Resistance to stress
2. Assessing the situation and making decisions – recognizing critical bleeding and choosing the right course of action
3. Teamwork in simulation – if VR is multiplayer, cooperation with other participants is necessary

DESCRIPTION OF THE SITUATION:

In front of the user lies a young man who is bleeding profusely from a deep wound on his forearm. Bright red blood is spurting from the wound.

His clothes are stained with blood and his breathing is fast and irregular. He looks up at the user with a frightened expression and says in a quiet voice: "Help me..." Next to him on the ground lies broken glass, probably the cause of his injuries. The user must make a quick decision – assess the condition of the injured person, stop the bleeding and ensure that the patient is safe before the ambulance arrives. In an interactive environment, they can choose various tools from the first aid kit, communicate with the patient and instruct surrounding witnesses to call for help. As soon as he begins to administer first aid, the scenario reacts dynamically – if he presses the bandage correctly on the wound, the bleeding slows down, but if he hesitates or uses the wrong technique, the patient begins to show signs of shock, which complicates the situation. The aim of this scenario is to simulate realistic first aid training under pressure, where the player learns to react correctly in a crisis situation.

DESCRIPTION OF THE ENVIRONMENT

The user finds himself on the street next to an injured person lying on the ground. The surrounding environment is busy – you can hear muffled voices of people, the distant sound of sirens and the hustle and bustle of the city. The surrounding houses are damaged by the earthquake. Curious passers-by are slowly gathering around

Tools and objects

List of the tools and objects …….

Fig. 2 Aids to stop bleeding

North American Rescue. (n.d.). Bleeding control kits trainer. AED Superstore. Retrieved April 25, 2025, from https://www.aedsuperstore.com/north-american-rescue-bleeding-control-kits-trainer.html

Interaction – what should the participant do?

Approach to the patient and initial reaction

- On-screen instructions: "You see an injured person bleeding profusely. Get close to it and find out its condition
- Interaction: The user approaches and receives visual and audible stimuli (bleeding, gasping for breath of the patient)

Choice (right and wrong action):

- Reach out to the patient and find out about his condition" (if the patient responds, the scenario continues)
- Ignore the patient and look for another solution" (warning that the patient needs to be addressed first)

User protection – putting on gloves

The user takes gloves and puts them on (does he choose them from the tools available via the tool icon?)

Identification of the source of bleeding and direct pressure

- The user clicks or grabs a sterile gauze and applies it to the wound
- If the pressure is too weak (can I do this with the joystick button?? – this may be an IT question), a warning will appear ("Push harder!")
- If the user does not intervene in time, a warning about patient shock will begin to appear

The wound is still bleeding

Application of pressure bandage

The user selects the right aids for the pressure bandage

The wound is still bleeding

Use of a tourniquet (if the bleeding is massive)

- The user takes the tourniquet, places it over the wound and tightens it
- If it tightens it correctly, the system will display confirmation

- If they deploy it too loosely, a warning and a repair option will appear

Call the ambulance and monitor the patient

- The user presses a button on the VR phone or asks a virtual character to call for help
- Then he monitors the patient, talks to him and checks his condition (breathing, reaction to stimuli)

Shock prevention

- The user takes the thermofoil and covers the patient.

Completion of the scenario – arrival of rescuers

- After all the steps have been carried out correctly, an animation of the arrival of the ambulance and the paramedics who are taking over the patient will appear
- At the end, the user's performance evaluation is displayed – for example, scores for correct and fast execution, effective selection of aids and evaluation of the entire case

Summary and Conclusion

Virtual Reality is a technology that enables users to enter and interact with a simulated environment using devices such as virtual reality headsets, controllers, or haptic tools. The key features of virtual reality include interactivity, immersive experiences, simulation of real-world situations, and sensory stimulation. One of the most important applications of virtual reality is in education and training, where it provides a safe, repeatable, and realistic learning environment.

Virtual reality allows learners to acquire both hard and soft skills with immediate feedback and a high level of engagement. To successfully create a virtual reality scenario, it is essential to define educational objectives, identify the target audience, design the environment, choose a platform, determine interaction methods, and develop a realistic description of the situation including characters and context.

A well-designed scenario should include initial instructions, decision-making moments, realistic elements, and user performance evaluation. A good scenario enhances user engagement and learning efficiency.Virtual Reality is a powerful tool for education and training, combining interactivity, realism, and safety.

The success of virtual reality applications depends on the quality of the scenario and the realism of interactions. Testing, user feedback, and continuous improvement are crucial. The future of virtual reality lies in integration with artificial intelligence and advanced haptic technologies, opening new possibilities in learning and professional development.

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