**This is the authors' version of the paper.**

**Final publication is available from Mary Ann Liebert, Inc.: http://dx.doi.org/10.1089/cyber.2023.0414**

Alessandro Forgiarini[a,b], Laura Deroma[c], Fabio Buttussi[a], Nicola Zangrando[b], Sabrina Licata[b], Francesca Valentc[c,d], Luca Chittaro[a], and Antonio Di Chiara[e].

# Introducing Virtual Reality in a STEMI Coronary Syndrome Course: Qualitative Evaluation with Nurses and Doctors.

Cyberpsychology, Behavior, and Social Networking. 2024.

[a]Human-Computer Interaction Laboratory, Department of Mathematics, Computer Science and Physics, University of Udine, Udine, Italy.

[b]Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy.

[c]Hygiene and Public Health Unit, Department of Prevention, Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy.

[d]Hygiene and Clinical Epidemiology Unit, Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy.

[e]Cardiology Tolmezzo, San Daniele-Tolmezzo Hospital, Azienda Sanitaria Universitaria Friuli Centrale, Udine, Italy.

**Keywords**

VR training - Medical Education - STEMI - Thematic Analysis

**Acknowledgments**

We gratefully thank nurses and doctors who enthusiastically volunteered to share their perceptions and opinions about the VR system and the entire training course.

**Funding Statement**

This work was supported by the Italian Ministry of Health (NET-2016-02364191) and by the Friuli Venezia Giulia Region, in the framework of the EASY-NET research program.

Part of Alessandro Forgiarini's work was supported by a Ph.D. grant from the Italian Ministry of University and Research (PNRR M4C1 Inv. 4.1 D.M. 351/2022).

**Authorship Contribution Statement**

Forgiarini Alessandro: Writing - original draft (equal); Writing - Review and editing (supporting); Visualization (lead).

Deroma Laura: Writing - original draft (equal); Formal analysis; Investigation (lead); Methodology (equal); Project administration (lead); Writing - review and editing (supporting).

Buttussi Fabio: Writing - original draft (equal); Methodology (equal); Review and editing (supporting).

Zangrando Nicola: Investigation (supporting); Software.

Licata Sabrina: Investigation (supporting).

Valent Francesca: Funding.

Chittaro Luca: Conceptualization (equal); Writing - review and editing (lead).

Di Chiara Antonio: Conceptualization (equal); Project administration (supporting); Resources.

**Authors' Disclosure**

All authors declare they have no conflicts of interest.

**Abstract**

In the increasing number of medical education topics taught with virtual reality (VR), the pre-hospital management of ST-segment elevation myocardial infarction (STEMI) had not been considered. This paper proposes an implemented VR system for STEMI training and introduces it in an institutional course addressed to emergency nurses and case manager doctors.

The system comprises three different applications to respectively allow i) the course instructor to control the conditions of the virtual patient, ii) the case manager to communicate with the nurse in the virtual field and receive from him/her the patient's parameters and electrocardiogram, iii) the nurse to interact with the patient in the immersive VR scenario.

We enrolled 17 course participants to collect their perceptions and opinions through a semi-structured interview. The thematic analysis showed the system was appreciated (n=17) and described as engaging (n=4), challenging (n=5), useful to improve self-confidence (n=4), innovative (n=5), and promising for training courses (n=10). Realism was also appreciated (n=13), although with some drawbacks (e.g., oversimplification; n=5). Overall, participants described the course as an opportunity to share opinions (n=8) and highlight issues (n=4) and found it useful for novices (n=5) and, as a refresh, for experienced personnel (n=6). Some participants suggested improvements in the scenarios' type (n=5) and variability (n=5). Although most participants did not report usage difficulties with the VR system (n=13), many described the need to get familiar with it (n=13) and the specific gestures it requires (n=10). Three suffered from cybersickness.

## Introduction

ST-segment elevation myocardial infarction (STEMI) is an acute life-threatening coronary syndrome caused by a complete thrombotic occlusion of a coronary artery branch, characterized by a peculiar electrocardiographic presentation, and representing a time-dependent emergency.[1] Appropriate therapy (primary percutaneous coronary intervention, stenting, thrombolysis) should be administered as quickly as possible to achieve a better prognosis and minimize permanent damage.[2]

Nurses and doctors in emergency medical services usually follow Advanced Life Support courses, consisting of theoretical and practical content and a final exam.[3] These courses provide specific skills to deal with cardiac arrest and peri-arrest situations, manage resuscitated patients until their transfer to an intensive care setting, and communicate effectively with the other rescue team members and the patient's family.[3] However, specific training courses to teach how to deal with STEMI patients are rare and based on role-playing simulations where different team members pose as STEMI patients, family members, or healthcare providers. Unfortunately, training experiences conducted by instructors suffer from high variability, issues in replicability, and subjective evaluation.[4–10]

In this context, Virtual Reality (VR) can provide important advantages such as training standardization, objective evaluation criteria, and large-scale distribution of the educational method to medical schools, emergency medical services, and hospitals.[7,11–13] In contrast to other digital media, VR allows the trainees to live a highly interactive experience that allows to learn by doing in a reproduction of the real-world context in which the learned concepts and procedures will be applied. This promotes a more effective learning, according to constructivist and situated learning theories.[14] Moreover, higher immersivity in terms of display and interaction can provide benefits in terms of presence in the Virtual Environment (VE) and engagement of trainees.[15,16] Furthermore, VR training may improve post-intervention knowledge and skills compared to traditional education.[17] In recent years, the medical field showed a growing interest in VR applications and produced flourishing scientific literature.[13,18–24] Moreover, the COVID-19 pandemic encouraged the adoption of this technology in medical education and training with positive effects.[25,26] In the context of cardiovascular medicine, VR is changing the training approach,[27–29] with simulation-based training especially used in interventional cardiology.[24] Nevertheless, to the best of our knowledge, no VR system has been yet proposed to train nurses and doctors in the STEMI pre-hospital management.

Therefore, this paper proposes a VR training system used to reproduce scenarios representing patients with out-of-hospital STEMI. The system engages two trainees simultaneously: an emergency nurse who manages the patient in the VE, and a case manager (CM) doctor in the real world. The CM can either be a cardiologist working in a coronary care unit or an emergency room doctor: they evaluate the clinical information and electrocardiogram received by the nurse, managing the patient’s pathway from diagnosis to treatment. The proposed VR system uses an audit and feedback strategy.[30] This aims to encourage healthcare professionals to improve clinical practice by correcting behaviors not meeting standards.

Moreover, the implemented VR system is used in an institutional Continuing Medical Education (CME) accredited training course, making it a blended learning course, where, at the end of each simulation, an instructor (cardiologist) conducts a debriefing and encourages discussion among participants. The qualitative evaluation in this paper concerns six editions of the course that took place between October 2022 and January 2023, in the Azienda Sanitaria Universitaria Friuli Centrale, Northeastern Italy. Among the 48 emergency nurses and 15 CM doctors who attended one of these editions, 17 participants volunteered to be interviewed about their experience with the VR system and the blended learning course. This paper presents the thematic analysis of their replies.

## The Proposed VR System for STEMI Training

The proposed system simulates the rescue operation of a STEMI patient in several scenarios characterized by different anamnestic data and vital parameters. The system comprises three applications used by one instructor and two trainees simultaneously:

- The *course instructor* uses a tablet-based Instructor Application (IA) to control different aspects of the simulation in real time (e.g., changing vital parameters) (Fig. 1, 5b, 5d; Supplementary Material S1 contains a detailed description).

- The *case manager doctor* uses a tablet-based Case manager Application (CA) that provides a phone call communication with the nurse, and displays the data sent by the nurse during the simulation (e.g., patient's electrocardiogram) (Fig. 2; Supplementary Material S1 for a detailed description).

- The *nurse* wears a VR headset (Meta Quest 2)[31] in which a Nurse Application (NA) displays the VEs. The three VEs included in the NA and the interactions they support are illustrated in Fig.1-3.

*VEs in the NA*

The three VEs (Fig. 3) represent the sequence of real-world environments encountered during a STEMI rescue: i) the crew room, ii) the ambulance, and iii) the patient's house.

In the first VE (Fig. 3a), the nurse can become familiar with the VR headset and hand tracking. The VE includes a table with the medical equipment to be used in the training scenarios (monitor with defibrillator, medication bag, smartphone, oxygen tank). In this scenario, the trainee does not use yet the equipment.

In the second VE (Fig. 3b), the nurse receives briefing information while reaching the emergency scene.

In the third VE (Fig. 3c), the nurse acts on the patient. Emergency equipment is placed near the nurse to minimize the need for walking around.

*Interaction*

The interactions (Fig. 4) supported by the NA exploit both head and hands tracking. The simulation was designed to allow for a natural interaction with the VE. The nurse can interact with the patient and the objects in the living room VE in four different ways:

- Movement. The nurse can move freely by walking directly to the desired location. We minimized the need for movement, ensuring that a simple rotation allows to reach objects and interact with them.
- Proximity. Some objects are automatically activated when the nurse's hand is close (e.g., when it approaches the pouches at the side of the monitor, they display their contents as in Fig. 4a) to simplify interaction with objects, allowing the nurse to focus on reasoning and learning about the medical procedures.

- Grasping. Objects can be grasped and moved by approaching them with the hand and performing the pinch gesture. Regardless of the object's size, when the fingers come in contact, the object is grasped and can be moved to the desired position. When the nurse moves the two fingers apart, the object is released. Some objects are automatically released if they are moved close to specific interaction points (e.g., the face mask in Fig 4b automatically sticks to the patient's face).
- Press. The monitor buttons can be pressed using the forefinger, as in the real world. The button lights up when the finger is sufficiently close (Fig 4c), indicating that continuing the movement will complete the interaction.

*Interactions with Objects*

The nurse can use all the tools typically used during a rescue:

- Monitor with defibrillator (LIFEPAK 15)[32] to monitor the patient's vital parameters. Several sensors (SpO2, band for noninvasive pressure measurement, peripheral and precordial leads and electrodes for electrocardiogram measurement, plates for external electrostimulation) are available in two side pouches attached to the monitor and must be applied to the patient to display his vital parameters. To allow for proper functionality during the rescue, the relevant monitor's functions are reproduced during the simulation: manual pressure measurement and setting automatic pressure measurement in preset time intervals; calculation of the 12-lead electrocardiogram and printing of the paper report; sending the electrocardiogram to the CM; administration of resuscitation discharges; and activation of external pacing. Fig. 4a and 4c show examples of interaction with the monitor.

- Oxygen cylinder and mask. A mask connected to an oxygen cylinder can be attached to the patient's mouth to administer oxygen (Fig. 4b), regulating its flow through an interface appearing at the cylinder's regulating valve.

- Medication bag. Pills, intravenous drugs, and intravenous bags can be administered to the patient during the simulation. All medications are contained in the medication bag (Fig. 4d) and can be accessed through an interface that opens as the user's hand approaches the bag.

- Smartphone. This device manages the communications between the nurse and the CM. When the nurse's hand approaches the smartphone in the scene, an interface appears to make, terminate, or answer a call (Fig. 4e).

*Interactions with the Patient*

The nurse can interact with the patient by applying sensors, oxygen masks, and administering medications. During the simulation, the instructor impersonates the patient, responding directly to questions the nurse asks.

The patient's representation in the VE adapts according to the vital parameters set by the instructor via the IA. The patient's state is visualized through facial animation, body animation, and skin characteristics, that change according to vital parameters (Fig. 5):

- When events that are painful to the patient occur, his face takes on increasingly pronounced suffering expressions. In case of fainting or deep sedation, eyelids are lowered.

- To give more direct visual feedback, the animations the patient performs change according to his consciousness, respiratory rate, and pain.

- The parameters representing the patient's skin are changed according to vital parameters, to simulate decreased perfusion or sweating.

*Use in the Course*

Each nurse tried one scenario using the NA during a 10-15 minutes session. Since there were less CM doctors than nurses, each doctor used the CA for one or more scenarios. While a nurse and a CM doctor tried a scenario, all the other participants watched the simulation on a projected screen displaying the VE as seen by the nurse and vital parameters of the patient as set in the IA. Therefore, although only nurses wore the VR headset during the simulations, all participants watched all the simulations they were not involved in. This participatory course approach was meant to allow nurses and doctors to gain the most from the experience.

**Methods**

The study's goal was to evaluate the perceptions and opinions of nurses and doctors attending the CME blended learning course with the VR system to train participants in rescuing STEMI patients. To this purpose, we conducted an interview consisting of a sequence of structured open-ended questions (Fig. 6). Questions were intentionally general and allowed to collect information from the point of view of both nurses and doctors. Data were analyzed by employing thematic analysis, as described by Braun and Clarke.[33] The study was approved by the Institutional Review Board of the Department of Mathematics, Computer Science, and Physics of the University of Udine.

*Participants*

Twelve nurses and five doctors (9M, 8F) among the course participants volunteered to be interviewed. All but one also provided information about their age, years of experience in the role and in the emergency area, and previous use of VR (Table 1).

Table 1. Participants' gender, age range, professional role, years of experience in the role and in the emergency area, and previous use of VR.

| Participant | Gender | Age range | Professional role | Years of experience in the role | Years of experience in emergency area | Previous use of VR |
|---|---|---|---|---|---|---|
| D1 | Male | 35-44 | Doctor | 10-14 | 10-14 | No |
| D2 | Male | 35-44 | Doctor | 10-14 | 10-14 | Yes |
| D3 | Female | 35-44 | Doctor | 5-9 | 5-9 | No |
| D4 | Female | 55+ | Doctor | 25-29 | 20-24 | Yes |
| D5 | Male | 35-44 | Doctor | 10-14 | <5 | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| N1 | Female | 55+ | Nurse | 25-29 | 5-9 | No |
| N2 | Female | 25-34 | Nurse | 5-9 | 5-9 | No |
| N3 | Male | 55+ | Nurse | 30-34 | 30-34 | No |
| N4 | Male | 35-44 | Nurse | 10-14 | 5-9 | No |
| N5 | Male | 25-34 | Nurse | 5-9 | 5-9 | No |
| N6 | Male | 25-34 | Nurse | 5-9 | <5 | Yes |
| N7 | Male | 45-54 | Nurse | 25-29 | 25-29 | Yes |
| N8 | Female | 25-34 | Nurse | 10-14 | 5-9 | Yes |
| N9 | Female | 25-34 | Nurse | 5-9 | <5 | Yes |
| N10 | Female | 45-54 | Nurse | 25-29 | 25-29 | Yes |
| N11 | Female | 45-54 | Nurse | 25-29 | 15-19 | No |
| N12 | Male | NA | Nurse | NA | NA | NA |

*Procedure*

At the end of the CME course, we asked participants if they would like to volunteer for a subsequent interview about the experience. The volunteers left their e-mail and phone number to be contacted and book an interview time slot. After the interviewer defined the available time slots and assigned an online meeting link for each of them, two other team members contacted the volunteers and sent them the privacy policy and the consent module. After receiving the signed consent, the team members recontacted each volunteer, arranged a time slot and then confirmed it via e-mail, also including an anonymous code and the instructions to blind their identity to the interviewer (i.e., join the meeting without using a personal account, use the anonymous code and not the real name, do not use a webcam, possibly apply a filter to change the voice). Participants were also informed that the interview would be audio recorded and then deleted after transcription. At the defined time slot, the interviewer met the participant online and started the audio recording. After briefly introducing the interview and inviting the participant to freely express opinions, taking the time needed to reason about them, the interviewer asked the open-ended questions following the flow in Fig. 6. When needed, the interviewer also asked some additional questions (e.g., what, when, how?) to clarify participants answers.

Each audio recording was saved with the participant's anonymous code and then verbatim transcribed. Two members of the research team, with different background (one in medicine and one in computer science), performed the thematic analysis by repeatedly listening to the interviews, checking the transcripts back against the original audio recording, actively reading the transcripts many times, generating initial codes using a data-driven approach to include all potentially interesting content, collating them into potential themes and subthemes, and finally reviewing and refining them to create a codebook.[33,34] The final themes and subthemes were chosen to describe the entire blended learning course (ReflectOnExperience, PositiveAspect, Critique) and the VR system (Realism, UsageDifficulty), and to acquire useful information for improvement (Proposal, Opinions). After agreeing on the codebook with the supervision of a third team member (a senior medical doctor), each of the coders independently assigned sub-themes to chunks of data extracted from the interviews using the Taguette software.[35] Then, the two coders discussed on the disagreements. In case of assignments for which no agreement was found, the third team member was involved to break the tie.

**Results**

The coders identified seven themes and 31 sub-themes in the interviews (Table 2; Supplementary Material S2 contains examples of participants' quotes).

After the independent assignment of the codes, Cohen's Kappa inter-coder reliability was 0.76 (95% CI 0.71-0.82). After discussion, the two coders reached an agreement on all but six assignments, which were decided by the third team member.

Table 2. Identified themes and sub-themes with their description and participants who talked about them.

| **Theme** | **Sub-theme** | **Description** | **Participants** |
|---|---|---|---|
| ReflectOn Experience | Yes | In the following weeks, the user reflected on the VR system / blended learning experience and / or talked about it with colleagues | D1; D2; D3; D4; N1; N2; N4; N5; N6; N7; N8; N10; N11; N12 |
| ReflectOn Experience | No | In the following weeks, the user did not reflect on the VR system / blended learning experience | D5; N3; N9 |
| PositiveAspect | Positive Experience | In general, participation in the course was perceived to be positive and enjoyable and/or valuable and/or the participant would not change anything of the experience | D1; D2; D3; D4; D5; N1; N2; N3; N4; N5; N6; N7; N8; N9; N10; N11; N12 |
| PositiveAspect | Engaging Learning | The experience is engaging and enables to memorize notions as effectively learned | D2; D5; N2; N12 |
| PositiveAspect | Innovative | The course uses innovative technology as compared to traditional courses | D1; D2; D3; N1; N2 |
| PositiveAspect | Technology Potential | The technology used is beneficial for this educational aim | D2; D3; N2; N3; N6; N7; N8; N9; N11; N12 |

| | | | |
|---|---|---|---|
| PositiveAspect | Retry | The user would have liked to try the system several times, perhaps with different scenarios | N3; N8 |
| PositiveAspect | Future Participation | The user would like more sessions of the course to be held | D5; N5; N11 |
| PositiveAspect | Realism | The experience during the course is like what happens during an actual rescue operation | D2; D3; D4; D5; N1; N2; N3; N4; N5; N8; N9; N10; N12 |
| PositiveAspect | Challenge | The user liked to challenge themselves and put their knowledge to the test | D2; D5; N2; N10; N11 |
| PositiveAspect | Increased Confidence | The course helped to increase the confidence level in one's knowledge | D2; N4; N6; N11 |
| PositiveAspect | SafeEnvironment | VR allows trainees to practice risky situations in a safe environment | N3; N6; N7 |
| PositiveAspect | ShareOpinions | The course can be a good opportunity to exchange views with others | D3; D4; N2; N4; N5; N6; N7; N10 |
| PositiveAspect | Highlighting Problems | The course is a good opportunity to highlight issues encountered during operations on the field | D2; D3; D4; N11 |
| PositiveAspect | Instructors Expertise | Course instructors are trained and experienced | D4; N4 |
| PositiveAspect | NoIssues | The user found no negative aspects in the experience | D1; D3; D4; D5; N5; N6 |
| Critique | Discomfort | The presence of other people makes the learner feel uncomfortable and under pressure | D4; N1; N7; N10; N11 |
| Critique | FamiliarTopics | The topics in the course are already known, nothing new is provided | D4; N1; N2; N7; N8; N9; N12 |
| Realism | Over Simplification | The system simplifies / speeds up some procedures that are not simple or that in the real world take a certain amount of time to perform | N1; N7; N8; N9; N10 |
| UsageDifficulty | MissingActions | It is not possible to perform within the system all the actions that would be performed during a rescue | D2; N7 |

| | | | |
|---|---|---|---|
| UsageDifficulty | Patient | The user stated that the patient is unrealistic, too still, and was not able to notice pallor or sweat | N7; N8; N12 |
| UsageDifficulty | Sensorial | Only sight and hearing are used; stimulation of the other senses is lacking | D2; N7; N10; N12 |
| UsageDifficulty | BecomeFamiliar | The user had difficulty since it was their first time using the system and they did not have a chance to become familiar with it before the test | D3; D4; D5; N1; N2; N3; N4; N7; N8; N9; N10; N11; N12 |
| UsageDifficulty | Interaction | Need to use unnatural gestures to interact with various elements | D2; D3; D4; N1; N2; N3; N7; N8; N9; N11 |
| UsageDifficulty | Cybersickness | The user reported experiencing headache or nausea or dizziness or mentioned that colleagues suffered from it | N2; N4; N9; N10; N12 |
| UsageDifficulty | None | No difficulties were identified in using the system | D1; D3; D4; D5; N1; N4; N5; N6; N8; N12 |
| Proposals | Environments | The user suggests increasing the inter-scenario variability to avoid making them too repetitive | D2; N3; N8; N10; N12 |
| Proposals | Uncommon Environments | The user suggests using this technology for creating unusual scenarios, which do not happen frequently | D2; N1; N3; N7; N11 |
| Proposals | Realism | The user wishes that the system was more like reality | D2; N1; N3; N6; N7; N9; N10 |
| Opinion | UsefulForNovices | Positive experience for new staff rather than people who have been working for years | D4; N1; N7; N9; N12 |
| Opinion | UsefulForExperts | For experienced staff it can be a good knowledge check, to repeat protocols | D2; D4; N2; N5; N6; N8 |

**Discussion**

The methodological paper by Pedram et al. recommends that VR systems should "provide motivation through enjoyment, satisfaction, engagement, attention and challenge"[36] and in other studies a positive experience was reported in terms of enjoyment,[26,37] satisfaction,[20,38,39] attentiveness,[20,26]motivation,[20] and acceptability and feasibility.[19] The results of our study confirm those of the literature in the context of

STEMI: all participants appreciated the course and the use of the VR system, and 14 out of 17 said they thought about the experience in the weeks following the course (Reflect on Experience theme).

All participants contributed to at least 3 sub-themes of the broad Positive Aspect theme and six did not find any negative aspects; the VR system was considered engaging (n=4), as reported in other studies,[19,20,40,41] innovative (n=5) and promising for training courses (n=10). For example, N2 reported "I think it gives you many extra things in specific courses. Because you really drop into the actual situation, and so you get yourself involved" and D3 declared "[I appreciated] the quality of the experience itself, the technique, and my experience. Moreover, the fact that I had not tried [something like that] before left me pleasantly surprised".

In addition, some participants would have liked to try more simulations (n=2) or more course sessions (n=3), as reported in other studies where the willingness to use a VR system again was described.[29,41]

The VR system was also described as an opportunity to test knowledge and skills in a safe environment (n=3), as positively described in previous work.[21,29] Some trainees described the blended learning course as an opportunity to discuss and exchange opinions (n=8) and to point out issues (n=4); for example, N11 reported: "There's a big gap between those who work on the ground and those who work in the hospital. They don't understand our situation, so they don't help us when requests are made". The presence of experienced instructors was also appreciated (n=2), consistently with other studies, where a supervisor and peer interaction were positively considered.[20,40]

Moreover, most participants reported that the VR experience was highly similar to what happens during actual emergency interventions (n=13), as in other studies.[26] For example, N5 reported: "It very much reflects reality. Of course, you emphasize a little bit more, in the sense that when you talk to the cardiologist, you lose a bit more time. However, it's a course that allows you to relate to the patient as you relate to them in the real world. And the treatments you do are the real ones, whether it's the ECG, administering the medications, or contacting the cardiologist, which is an important thing anyway" and it is interesting to note that realism was appreciated both by doctors and nurses, although only nurses lived the VR experience using the VR headset, while all participants watched it on the projected screen. However, some participants complained about the procedures' oversimplification (n=5) and missing actions (n=2) and suggested to improve realism (n=7), as in Hood et al. [41] For example, under the Realism theme, N10 reported: "Instead, the difficulty and the time to do those tasks in the real world are not like that. That is, the fact that I touched the wires and brought them to the patient was instantaneous. In a real situation, it takes me several seconds in which more questions can be processed, and I take more time to think about what I need to do. It was too fast."

Participants also showed their interest (Proposal and Opinion themes) suggesting to modify scenarios to increase their variability (n=5; e.g. D2: "Maybe trivially change the structure of the room or the patient lying down or finding them in bed or on the stairs"), like requested in another study,[41] and to describe infrequent situations (n=5). Five participants reported it could be beneficial to naive health personnel (N1: "I would have done them very gladly at the beginning of my career"), while six reported that experienced personnel could benefit from it as a refresher training.

Nine participants contributed to the Critique theme, seven of them describing the blended learning course as not useful for them because they already knew the topics and five reporting discomfort and embarrassment due to the presence of other people (e.g. D4: "There were still many people, and somehow [I had] the feeling of being a little bit under examination). On the other hand, four found the course beneficial to improve self-confidence and five said that they liked the challenge. For example, D2 reported: "Well, let's say [the system also helps] to understand the difficulties in interfacing with practitioners who are not your colleagues. I'm used to being a case manager for my nurses who, in short, I know off the top of my head, so I know what I [expect] when someone tells me something, and [I understand] what they mean. When I give directives, I know what is received. Doing it instead with people I don't know is definitely something that, let's say, is very helpful". Challenge was indeed one of the aims suggested by Pedram et al.[36] and the trainee confidence following the VR training was already described as an advantage in previous studies.[19,26]

The Usage Difficulty theme revealed that ten did not mention any but a few participants thought the virtual patient was too static, finding it difficult to appreciate clinical signs such as paleness or sweating (n=3), or felt the interaction limited by the only use of sight and hearing (n=4). Moreover, thirteen reported the need to get familiar with the system and ten to learn specific interaction gestures (e.g. N8: "I found myself not performing things that I have performed, as if my intervention was not detected by the instrument"). This happened despite all participants were invited to watch a video tutorial before attending the course. These results are consistent with those described by other authors[25,40,41] and explain the recommendation for VR knowledge or practice before approaching VR systems for medical education.[40]

Finally, three participants suffered dizziness or nausea; this was expected, since cybersickness represents a known drawback of VR systems.[40,42]

There are different positive aspects to notice about the system and the course. We implemented a VR system that supports all control requirements recommended by Pedram et al.:[36] i) including "gesture recognition", ii) providing "motion sensitivity of controls", iii) meeting "minimum position tracking thresholds", iv) enabling "kinesthetic manipulation of virtual objects of interest", v) providing "efficient movement controls", vi) providing "control element granularity commensurate with the virtual layout needed". Moreover, it provides "effective feedback to the user",[36] both during the simulation (when the patient reacts to the user's actions) and at the end, through a description of the steps and their correctness. Participants in Hood et al.[41] appreciated feedback on timing and decision making and asked for more specific feedback, such as more information on mistakes. In our study, further feedback was provided by the instructor, a senior cardiologist complementing VR simulation.

As recommended by Pedram et al.,[36] visual and auditory cues (e.g., monitor's display contents and sounds) are also provided, while haptic cues are currently missing. As for the course, training was performed in small groups (from 6 to 13 participants), and this is described as a facilitator aspect.[40] Moreover, in contrast to another study, where the roles of distinct health workers were not differentiated, resulting in the disappointment of participants,[41] nurses and doctors played their own roles in our system and their collaboration was accurately reproduced, as also reported by some participants. This partnership is essential in the STEMI patient rescue, since the emergency nurse on the field and the doctor in the hospital need to work together to save the patient's life.

Costs are traditionally mentioned among the limitations of VR systems,[20,25] of which users are also aware.[40] However, we specifically implemented our system to run on the low-cost Meta Quest 2 VR headset.[31] Moreover, cost-effectiveness may improve if economic costs are analyzed in the long-term, and counterbalanced by potential risks and medical errors that could be avoided thanks to a training conducted in a safe environment.[29]

## Conclusions

This is the first proposal and study of a VR system to train nurses and doctors in the pre-hospital management of STEMI patients. The system was embedded in a CME course, making it a blended learning course. We performed a thematic analysis of the answers of course participants who volunteered to be interviewed. This possibly led to a self-selection of those more interested and satisfied and to a consequent overestimation of the blended learning course and VR system. An additional limitation was the small sample size, even though representative of the highly specialized healthcare personnel who deal with pre-hospital STEMI emergencies. In addition, the interviews did not take place immediately after the course and this allowed participants to reflect on the course, but it could also have caused memory fading and detail loss.

The analysis showed that all participants perceived the VR system and the blended learning course as a positive experience and provided interesting feedback on positive aspects and possible areas of improvement.

Following the advice, we worked on additional scenarios to increase variety. Moreover, we plan to improve the VR system as an evaluation tool and use it to compare the performance of participants of the course with the performance of nurses and doctors who had not yet attended the course, to quantitatively measure the effectiveness of the proposed form of VR-based medical education.

As the main implication for practice, this study highlighted that a VR system integrated in a blended learning course with a strong collaborative approach is much appreciated by all participants and could be inspiring when designing novel medical education programs for nurses and doctors. Interestingly, the training course also received a positive reaction at the regional level and was included in the current Training Plan of the Friuli Venezia Giulia Region, thus allowing nurses and doctors to receive a consistent education, smoothing possible geographical differences.

## Bibliography


1. Collet J-P, Thiele H, Barbato E, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: The Task Force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J 2021;42(14):1289–1367; doi: 10.1093/eurheartj/ehaa575.

2. Kingma JG. Myocardial Infarction: An Overview of STEMI and NSTEMI Physiopathology and Treatment. World J Cardiovasc Dis 2018;08(11):498–517; doi: 10.4236/wjcd.2018.811049.

3. ERC. Bringing Resuscitation to the World. 2023. Available from: https://www.erc.edu/courses/advanced-life-support [Last accessed: 7/31/2023].

4. Kaye W, Rallis SF, Mancini ME, et al. The problem of poor retention of cardiopulmonary resuscitation skills may lie with the instructor, not the learner or the curriculum. Resuscitation 1991;21(1):67–87; doi: 10.1016/0300-9572(91)90080-I.

5. Wynne G, Marteau T, Evans TR. Instructors—A Weak Link in Resuscitation Training. J R Coll Physicians Lond 1992;26(4):372–373.

6. Ratanawongsa N, Thomas PA, Marinopoulos SS, et al. The reported validity and reliability of methods for evaluating continuing medical education: a systematic review. Acad Med J Assoc Am Med Coll 2008;83(3):274–283; doi: 10.1097/ACM.0b013e3181637925.

7. Hansen C, Bang C, Stærk M, et al. Certified Basic Life Support Instructors Identify Improper Cardiopulmonary Resuscitation Skills Poorly: Instructor Assessments Versus Resuscitation Manikin Data. Simul Healthc 2019;14(5):281; doi: 10.1097/SIH.0000000000000386.

8. Stærk M, Vammen L, Andersen CF, et al. Basic life support skills can be improved among certified basic life support instructors. Resusc Plus 2021;6:100120; doi: 10.1016/j.resplu.2021.100120.

9. Ko Y, Hsieh M, Cheng A, et al. Faculty Development Approaches for Life Support Courses: A Scoping Review. J Am Heart Assoc 2022;11(11):e025661; doi: 10.1161/JAHA.122.025661.

10. Wyckoff MH, Greif R, Morley PT, et al. 2022 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. Circulation 2022;146(25):e483–e557; doi: 10.1161/CIR.0000000000001095.

11. Collins JP, Harden RM. AMEE Medical Education Guide No. 13: real patients, simulated patients and simulators in clinical examinations. Med Teach 1998;20(6):508–521; doi: 10.1080/01421599880210.

12. Pottle J. Virtual reality and the transformation of medical education. Future Healthc J 2019;6(3):181–185; doi: 10.7861/fhj.2019-0036.

13. Lie SS, Helle N, Sletteland NV, et al. Implementation of Virtual Reality in Health Professions Education: Scoping Review. JMIR Med Educ 2023;9(1):e41589; doi: 10.2196/41589.

14. Chittaro L, Ranon R. Web3D technologies in learning, education and training: Motivations, issues, opportunities. Comput Educ 2007;49(1):3–18; doi: 10.1016/j.compedu.2005.06.002.

15. Buttussi F, Chittaro L. Effects of Different Types of Virtual Reality Display on Presence and Learning in a Safety Training Scenario. IEEE Trans Vis Comput Graph 2018;24(2):1063–1076; doi: 10.1109/TVCG.2017.2653117.

16. Buttussi F, Chittaro L. A Comparison of Procedural Safety Training in Three Conditions: Virtual Reality Headset, Smartphone, and Printed Materials. IEEE Trans Learn Technol 2021;14(1):1–15; doi: 10.1109/TLT.2020.3033766.

17. Kyaw BM, Saxena N, Posadzki P, et al. Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration. J Med Internet Res 2019;21(1):e12959; doi: 10.2196/12959.

18. Zhao G, Fan M, Yuan Y, et al. The comparison of teaching efficiency between virtual reality and traditional education in medical education: a systematic review and meta-analysis. Ann Transl Med 2021;9(3):252; doi: 10.21037/atm-20-2785.

19. Dhar E, Upadhyay U, Huang Y, et al. A scoping review to assess the effects of virtual reality in medical education and clinical care. Digit Health 2023;9:20552076231158022; doi: 10.1177/20552076231158022.

20. Turan Z, Karabey SC. The use of immersive technologies in distance education: A systematic review. Educ Inf Technol 2023; doi: 10.1007/s10639-023-11849-8.

21. Ryan GV, Callaghan S, Rafferty A, et al. Learning Outcomes of Immersive Technologies in Health Care Student Education: Systematic Review of the Literature. J Med Internet Res 2022;24(2):e30082; doi: 10.2196/30082.

22. Car LT, Kyaw BM, Teo A, et al. Outcomes, Measurement Instruments, and Their Validity Evidence in Randomized Controlled Trials on Virtual, Augmented, and Mixed Reality in Undergraduate Medical Education: Systematic Mapping Review. JMIR Serious Games 2022;10(2):e29594; doi: 10.2196/29594.

23. Mergen M, Meyerheim M, Graf N. Reviewing the current state of virtual reality integration in medical education – a scoping review protocol. Syst Rev 2023;12(1):97; doi: 10.1186/s13643-023-02266-6.

24. Pezel T, Coisne A, Bonnet G, et al. Simulation-based training in cardiology: State-of-the-art review from the French Commission of Simulation Teaching (Commission d'enseignement par simulation–COMSI) of the French Society of Cardiology. Arch Cardiovasc Dis 2021;114(1):73–84; doi: 10.1016/j.acvd.2020.10.004.

25. Pallavicini F, Pepe A, Clerici M, et al. Virtual Reality Applications in Medicine During the COVID-19 Pandemic: Systematic Review. JMIR Serious Games 2022;10(4):e35000; doi: 10.2196/35000.

26. Sadek O, Baldwin F, Gray R, et al. Impact of Virtual and Augmented Reality on Quality of Medical Education During the COVID-19 Pandemic: A Systematic Review. J Grad Med Educ 2023;15(3):328–338; doi: 10.4300/JGME-D-22-00594.1.

27. Vandermolen S, Ricci F, Chahal CAA, et al. 'The Digital Cardiologist': How Technology Is Changing the Paradigm of Cardiology Training. Curr Probl Cardiol 2022;47(12):101394; doi: 10.1016/j.cpcardiol.2022.101394.

28. Skalidis I, Muller O, Fournier S. CardioVerse: The cardiovascular medicine in the era of Metaverse. Trends Cardiovasc Med 2022; doi: 10.1016/j.tcm.2022.05.004.

29. Aslani N, Behmanesh A, Garavand A, et al. The Virtual Reality Technology Effects and Features in Cardiology Interventions Training: A Scoping Review. Med J Islam Repub Iran 2022;36:77; doi: 10.47176/mjiri.36.77.

30. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database Syst Rev 2012;(6):CD000259; doi: 10.1002/14651858.CD000259.pub3.

31. Meta. Meta Quest 2: Immersive All-In-One VR Headset. 2023. Available from: https://www.meta.com/quest/products/quest-2/ [Last accessed: 7/31/2023].

32. Physio-Control. LIFEPAK 15 Monitor/Defibrillator. 2023. Available from: https://www.stryker.com/us/en/emergency-care/products/lifepak-15.html [Last accessed: 7/31/2023].

33. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2006;3(2):77–101; doi: 10.1191/1478088706qp063oa.

34. DeCuir-Gunby JT, Marshall PL, McCulloch AW. Developing and Using a Codebook for the Analysis of Interview Data: An Example from a Professional Development Research Project. Field Methods 2011;23(2):136–155; doi: 10.1177/1525822X10388468.

35. Rampin R, Rampin V, DeMott S. Taguette, the Free and Open-Source Qualitative Data Analysis Tool. 2023. Available from: https://www.taguette.org/ [Last accessed: 7/31/2023].

36. Pedram S, Kennedy G, Sanzone S. Toward the validation of VR-HMDs for medical education: a systematic literature review. Virtual Real 2023; doi: 10.1007/s10055-023-00802-2.

37. Galvez R, Wallon RC, Shackelford L, et al. Use of Virtual Reality to Educate Undergraduate Medical Students on Cardiac Peripheral and Collateral Circulation. Med Sci Educ 2021;31(1):19–22; doi: 10.1007/s40670-020-01104-x.

38. Chang S-L, Kuo M-J, Lin Y-J, et al. Virtual reality informative aids increase residents' atrial fibrillation ablation procedures-related knowledge and patients' satisfaction. J Chin Med Assoc 2021;84(1):25; doi: 10.1097/JCMA.0000000000000464.

39. Kim H-Y, Kim E-Y. Effects of Medical Education Program Using Virtual Reality: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health 2023;20(5):3895; doi: 10.3390/ijerph20053895.

40. Saab MM, Hegarty J, Murphy D, et al. Incorporating virtual reality in nurse education: A qualitative study of nursing students' perspectives. Nurse Educ Today 2021;105:105045; doi: 10.1016/j.nedt.2021.105045.

41. Hood RJ, Maltby S, Keynes A, et al. Development and Pilot Implementation of TACTICS VR: A Virtual Reality-Based Stroke Management Workflow Training Application and Training Framework. Front Neurol 2021;12; doi: 10.3389/fneur.2021.665808.

42. Weech S, Kenny S, Barnett-Cowan M. Presence and Cybersickness in Virtual Reality Are Negatively Related: A Review. Front Psychol 2019;10; doi: 10.3389/fpsyg.2019.00158.

## Figures

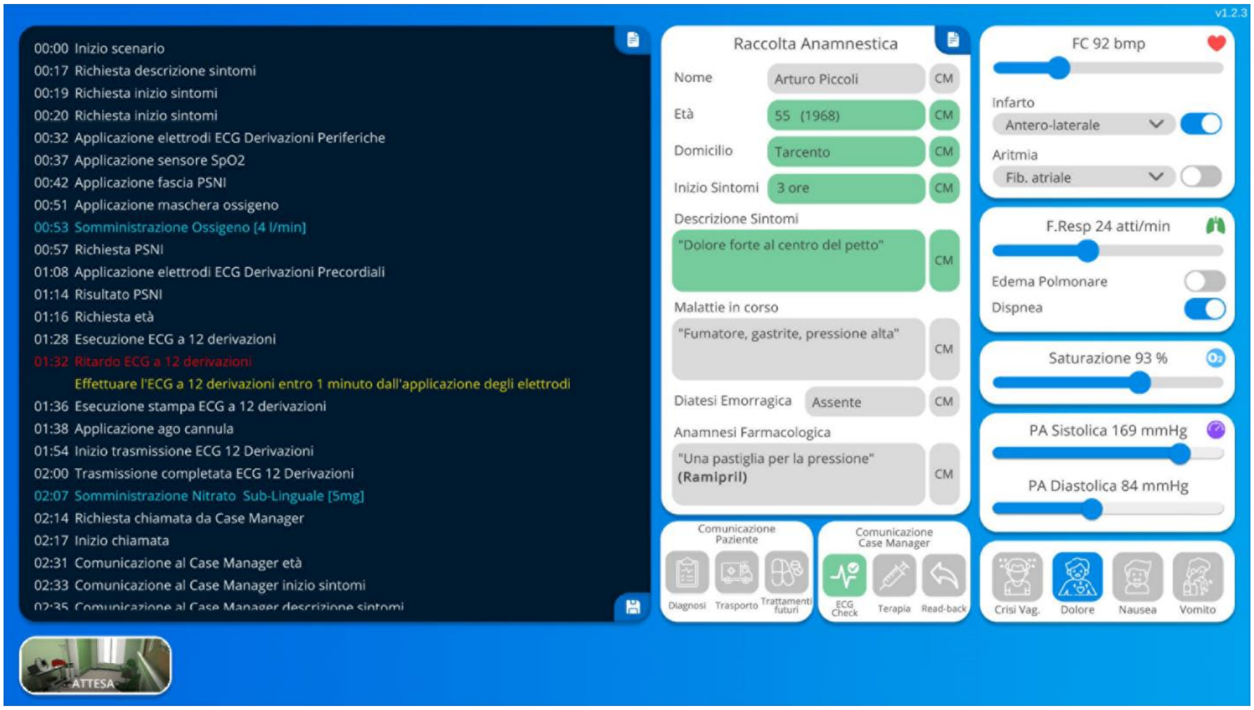


**FIG. 1.** The user interface of the Instructor Application, localized in the language of course instructors.

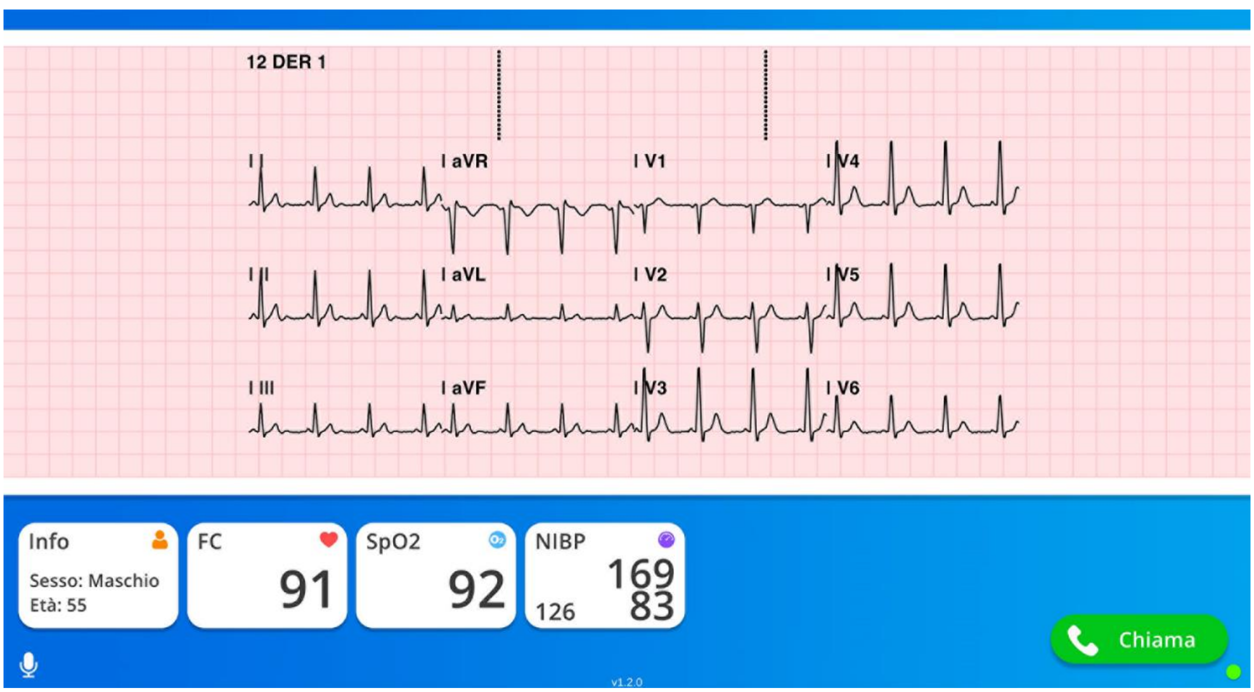


**FIG. 2.** The user interface of the Case manager Application, localized in the language of case manager doctors who attended the course.


**FIG. 3.** The Virtual Environments for nurse's training: a) crew room, b) ambulance, c) patient's house.

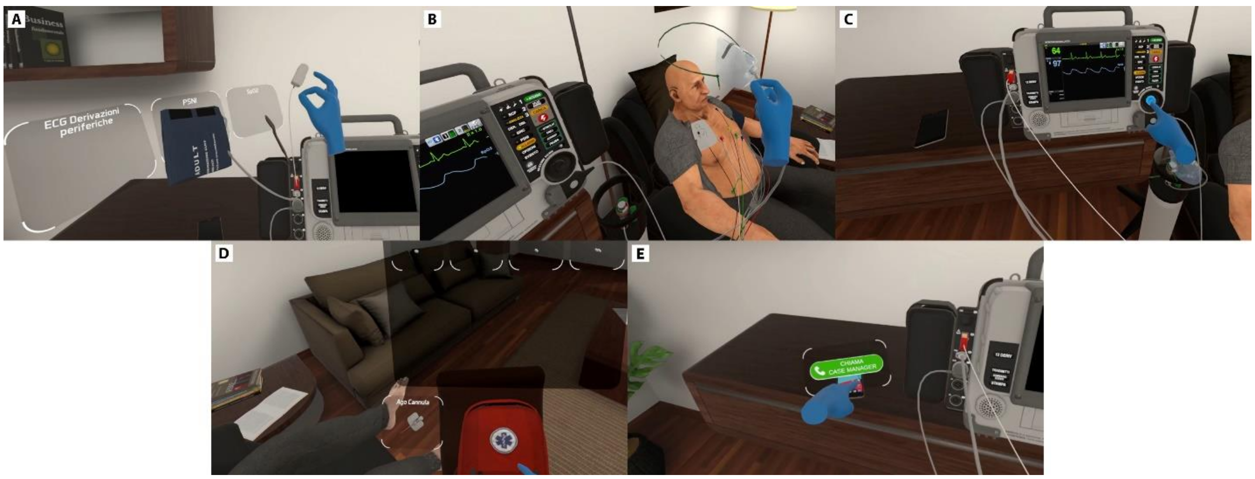


**FIG. 4.** Different interactions in the Nurse Application: a) interaction with the monitor bag, that opens when the hand is near it; b) pinch interaction with the oxygen mask; c) press interaction with the monitor buttons; d) interaction with the open medication bag; e) interaction with the smartphone.

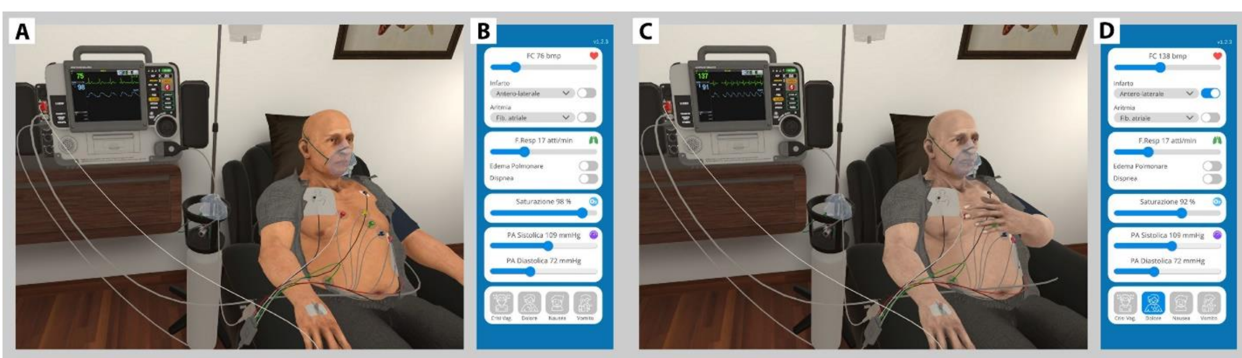


**FIG. 5.** Changes in patients' appearance and monitor (a and c) when the instructor changes parameters (b and d) from an initial state (a and b) to a worse state (c and d) where the instructor increased the heart rate, applied an intercostal pain, changed the oxygen saturation of the blood, and caused an antero-lateral infarct, resulting in a change in the vital parameters on the monitor and in the patient's skin color and left hand position.

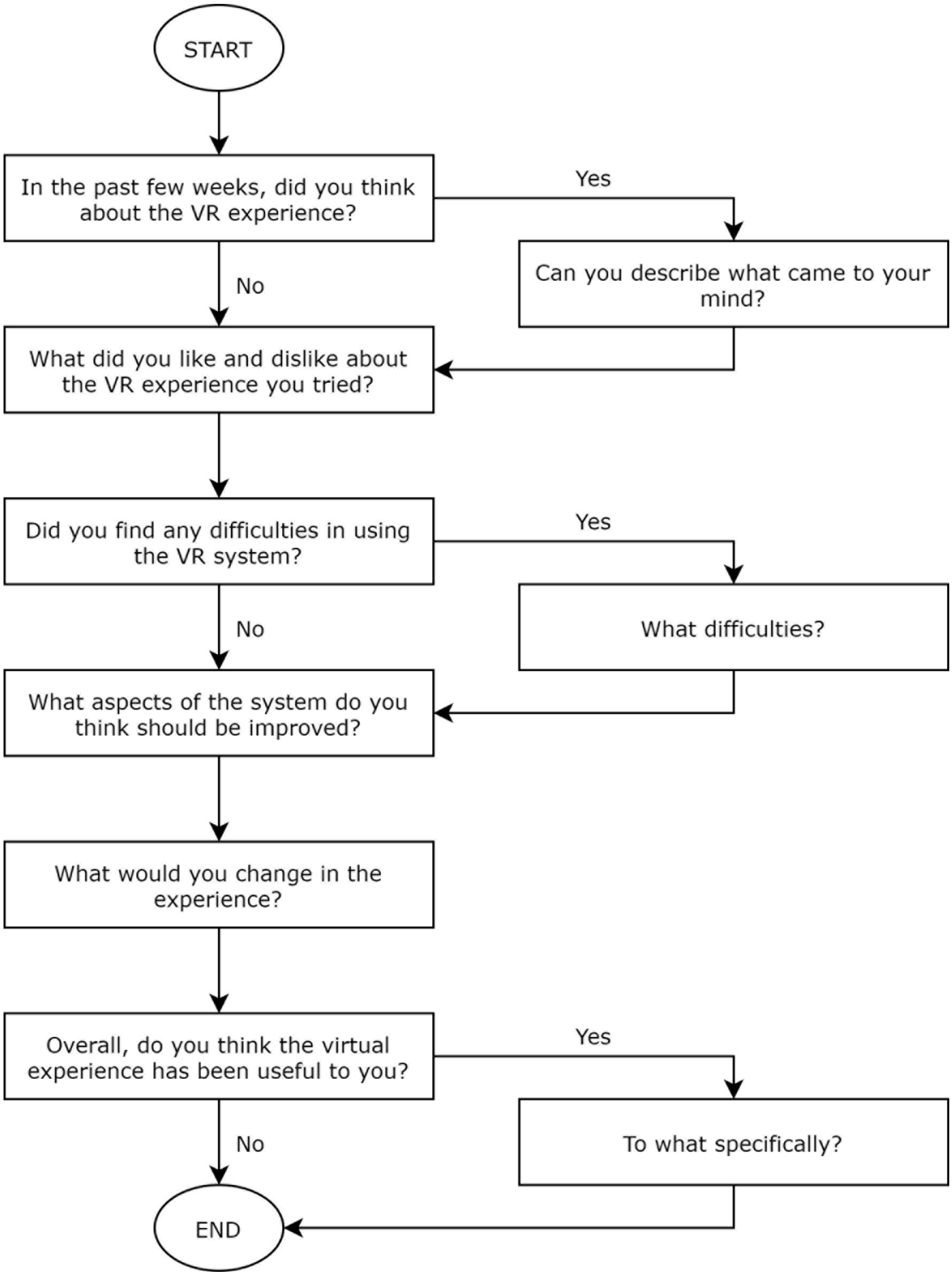


**FIG. 6.** Flow diagram of questions in the interview. The interview was conducted in the language of participants. Sentences have been translated here for readers' convenience.

**Supplementary Material S1**

*Instructor Application*

The IA manages the entire simulation. In addition to serving as a server for communication between the various devices, its functionalities include:

- Loading premade scenarios.
- Real-time modification of the patient's vital parameters during the simulation.
- Managing the loading of the different scenes.
- Storing the actions performed by the nurse during the simulation.

Before the simulation starts and during its execution, the instructor can change the patient's vital parameters by using the graphical interface in the application, as shown in Fig. 1. The interface is divided into four parts: i) the left side contains the log of every action the nurse had performed in the simulation; ii) the center part contains the anamnestic data of the patient for the simulation; iii) the right side contains the current state of the patient that can be updated in real-time by the trainer; iv) the bottom part let the instructor load the different VEs.

The anamnestic data of the patient comprise name, age, domicile, time of the beginning of the symptoms, description of symptoms, current illnesses, presence of hemorrhagic diathesis, and which medications have already been taken by the patients. The patient's vital parameters are heart rate, presence and type of infarction, presence and type of arrhythmia, respiratory rate, presence of pulmonary edema or dyspnea, blood saturation, blood and systolic pressure, presence of vagal seizure, presence of pain, and presence of nausea and vomiting.

As the instructor changes the patient's status, it is transmitted to the simulation running in the VR headset, and the virtual patient changes according to the updated values of the vital parameters. Fig. 5 shows an example of changes in the virtual patient's status.

The IA is also responsible for storing all the actions performed by the nurse, changes in the patient's vital parameters by the instructor, details on calls made between the case manager doctor and nurse (timestamp and the subject of request events, call initiation and termination), and communication events between nurse, patient, and case manager doctor indicated by the instructor.

During scenario simulation, feedback messages are displayed in the control app corresponding to errors the nurse performs during the rescue.

From the analysis of the generated log file, the application generates a final report that identifies whether specific actions necessary for the proper execution of a rescue intervention were performed correctly.

*Case manager Application*

The case manager is the medic responsible for the management of the patients. They can talk with the nurse via a phone call and receive the data gathered by the nurse in the simulation. The data concerns vital information about the patient as the 12-derivations ECG track, blood pressure, and heart rate.

Fig. 2 shows the interface of the Case Manager application. It shows the patient's data mentioned above and two buttons to handle the call with the nurse (answer the phone call and mute microphone).

**Supplementary Material S2**

In this supplementary material, we illustrate in more depth the results of the qualitative analysis by including sample interview extracts. In the extracts, the parts in square brackets are words or phrases added to clarify the sentence.

ReflectOnExperience_Yes

Fourteen people reflected on the virtual reality experience and/or talked about it with colleagues in the following weeks.

N4 - I've thought about it.

ReflectOnExperience_No

Three people did not reflect on the virtual reality experience in the following weeks. For example:

N9 – No.

PositiveAspect_PositiveExperience

Seventeen people perceived participation in the course to be positive and enjoyable and/or valuable and/or would not change anything of the experience. For example:

D3 - We can simply say I liked it.

PositiveAspect_EngagingLearning

Four people praised the application stating that the experience engages those who experience it and enables them to memorize the notions effectively learned. For example:

N2 – [This mode of explaining a topic] is very active learning.

PositiveAspect_Innovative

Five people praised the innovative technology of the course compared to the traditional material used in other lessons. For example:

D3 - [I appreciated] the quality of the experience itself, the technique, and my experience. Moreover, the fact that I had not tried [something like that] before left me pleasantly surprised.

PositiveAspect_TechnologyPotential

Ten people told us how the technology used is beneficial for this educational aim. For example:

N2 - I think it gives you many extra things in specific courses. Because you really drop into the actual situation, and so you get yourself involved.

PositiveAspect_Retry

Two people would have liked to try the system several times, perhaps with different scenarios.

N8 - I would maybe try a few more times. We each tried once. Possibly in the idea of having more time, it would be nice to do several different scenarios and try several times.

PositiveAspect_FutureParticipation

Three people would like more sessions of the course to be held. For example:

N5 - The only thing I hope is that it is a course that is done every year because it fits, as I said before, relating to the various figures, in my opinion, is essential, as far as our work is concerned.

PositiveAspect_Realism

Thirteen people stated how the experience during the course is like what happens during an actual rescue operation.

N5 - It very much reflects reality. Of course, you emphasize a little bit more, in the sense that when you talk to the cardiologist, you lose a little bit more time. However, it's a course that allows you to relate to the patient as you relate to them in the real world. And the treatments you do are the real ones, whether it's the ECG, administering the medications, or contacting the cardiologist, which is an important thing anyway.

PositiveAspect_Challenge

Five people appreciated challenging themselves by putting their knowledge to the test.

D2 - Well, let's say [that the application also helps] to understand the difficulties in interfacing with practitioners who are not your colleagues. I'm used to being a case manager for my nurses who, in short, I know off the top of my head, so I know what I [expect] when someone tells me something, and [I understand] what they mean. When I give directives, I know what is received. Doing it instead with people I don't know is definitely something that, let's say, is very helpful.

PositiveAspect_IncreasedConfidence

Four people praised the course for helping them to increase the confidence level of their knowledge. For example:

N4 - In my opinion, it gives you more confidence; afterward, you will know what to do in the real world [when you are in similar situations].

PositiveAspect_SafeEnvironment

Three people praised the safety of the virtual environment, stating that it is possible to practice handling risky situations in a protected environment. For example:

N3 – This [mode of learning] is the middle ground. It allows you to apply practical theory while being in a safe scenario.

PositiveAspect_ShareOpinions

Eight people told us how the course can be a good opportunity to exchange views with others.

N7 - I liked the fact that we still got together with different operators from the same company. We have become a big company now, so this is a time to meet [with other colleagues].

PositiveAspect_HighlightingProblems

Four people praised the course as an opportunity to highlight issues encountered during operations on the territory. For example:

N11 - There is a big gap between those who work on the ground and those who work in the hospital. They don't understand our situation, so they don't help us when requests are made.

PositiveAspect_InstructorsExpertise

Two people expressed how the course instructors were well-trained and experienced.

N4 - The interlocutors, that is those who empathized with the part, were also realistic, so it was a very good experience.

PositiveAspect_NoIssues

Six people did not report any negative aspects of the experience. For example:

D1 - In fact, there is not one thing that I did not like.

Critique_Discomfort

Five people report how the presence of other people makes them feel uncomfortable and under pressure. For example:

D4 - There were still many other people, and somehow [I had] the feeling of being a little bit under examination.

Critique_FamiliarTopics

Seven people report how the topics in the course are already known, and so nothing new is provided for them. For example:

N7 - So, honestly, that course was not helpful to me in the sense that all the topics that were being talked about I have already consolidated over time.

Realism_OverSimplification

Five people report how the system simplifies or speeds up some procedures that are not simple or that, in the real world, take a certain amount of time to be performed. For example:

N10 - Instead, the difficulty and the time to do those tasks in the real world are not like that. That is, the fact that I touched the wires and brought them to the patient was instantaneous. In a real situation, it takes me several seconds in which more questions can be processed, and I take more time to think about what I need to do. It was too fast.

UsageDifficulty_MissingActions

Two people complained about the lack of the possibility to perform within the system all the actions that would normally be performed during a rescue. For example:

D2 - It certainly wasn't entirely realistic, having to be limited to two or three actions that need to be codified at some point.

UsageDifficulty_Patient

Three people stated that the patient is unrealistic, too still, and there is no noticeable pallor or sweat. For example:

N8 - The operator was giving some somewhat nonspecific information that then, in the mannequin within the virtual reality, you could not see. The person was standing there, so there was a moment of inconsistency.

UsageDifficulty_Sensorial

Four people reported how only sight and hearing are used, leading to a lacking of stimulation of the other senses. For example:

D2 - The learner perceives not only by hearing and with sight but with all the senses, including touch and smell.

UsageDifficulty_BecomeFamiliar

Thirteen people had difficulties with the system since it was their first time using it, and they did not have a chance to become familiar with it before the test. For example:

N2 - You have to get a little bit of practice with this kind of technology.

UsageDifficulty_Interaction

Ten people had difficulties interacting with the system because of the need to use unnatural gestures to interact with various elements. For example:

N8 - I found myself not performing things that I have performed, as if my intervention was not detected by the instrument.

UsageDifficulty_Cybersickness

Five people reported experiencing headaches, nausea, dizziness, or colleagues suffering from it. For example:

N2 - To some people who were with me at the course, the system made them a little dizzy.

UsageDifficulty_None

Ten people reported no difficulties when using the system. For example:

D5 – The tablet that was being provided and the communications were both [good] at the level of technology and the degree of communication; I think they were absolutely congruent with the situation [we were facing].

Proposals_Environments

Five people suggest increasing the inter-scenario variability to avoid making them too repetitive. For example:

D2 - Maybe trivially change the structure of the room or the patient lying down rather than finding them in bed or on the stairs. [These situations] in practice often change the practitioner's approach.

Proposals_UncommonEnvironments

Five people suggest using this technology to create unusual scenarios which do not happen frequently. For example:

D2 - In the sense that along the lines of this course, I think so many other kinds of pathways can be done, right? I'm thinking of the stroke pathway rather than a trauma pathway, the shock patient pathway, that is, in those in which you have to add the figure of the central doctor.

Proposals_Realism

Seven people wish that the system was more similar to reality. For example:

N9 - So, the monitor definitely maybe needs to be fixed a little bit in the sense that it's not really very accurate. When you go to press some of the times, it takes one thing for another. And the backpack definitely, the medication backpack, is not really with the proper dosages. In my opinion, the medication dosages should be adjusted a little bit.

Opinion_UsefulForNovices

Five people think that the experience is more positive for new staff rather than for people who have been working for years. For example:

N1 - I would have done them very gladly at the beginning of my career.

Opinion_UsefulForExperts

Six people think the system could be a good knowledge check to repeat protocols for experienced staff. For example:

N2 - You have to [already] know the things. It's not like you learn them there. I mean, it could be a suitable method of verifying learning and not so much for education because the things that we learned, I mean, in my opinion, [within the system] we verified what we know or not during the course, we didn't learn new things.