Virtual Reality in training: A multidimensional analysis of technologies, challenges and paradigms

Razvan DUTESCU, Mihai APOSTOL, Ionut MOCANU, Monica BARBU

National Institute for Research & Development in Informatics – ICI Bucharest, Bucharest, Romania

razvan.dutescu@ici.ro, mihai.apostol@ici.ro, ionut.mocanu@ici.ro, monica.barbu@ici.ro

Abstract: *This paper explores the adoption of Virtual Reality (VR) and Extended Reality (XR) in professional training, demonstrating their potential to revolutionize learning by providing immersive, interactive environments that mimic real-world scenarios. Our review spans several sectors, including healthcare, engineering, and defense, and assesses how VR and XR enhance engagement, knowledge retention, and training efficiency. Results indicate that these technologies not only personalize learning experiences but also reduce costs and increase training accessibility. Finally, we present a framework for a multipurpose VR training application. The conclusion highlights the need for continued research to fully harness the capabilities of VR and XR in training programs.*

Keywords: immersive technologies, skill acquisition, virtual training, personalized learning, simulation environments.

1. Introduction

Virtual Reality (VR) and Extended Reality (XR) technologies are increasingly becoming vital tools in training across various sectors due to their unique ability to create simulated, controlled environments. This paper explores the application and benefits of these technologies in enhancing training programs, particularly focusing on areas where traditional training poses challenges due to safety, cost, or logistical issues.

Moreover, VR and XR technologies are transforming training across various sectors by creating simulated, realistic environments that mitigate physical risks. This evolution is further underscored by the emergence of the Metaverse, which extends these technologies into new realms of immersive interaction, potentially revolutionizing professional training programs (Petre et al., 2023).

The introduction of VR - entirely virtual environments - and XR - a blend of real and virtual elements into training frameworks allows learners to experience and interact with realistic scenarios without the risks associated with physical environments. For instance, in medical training, VR and XR can simulate surgical

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procedures allowing trainees to practice without any danger to patients. Similarly, in fields like aerospace and defence, these technologies provide realistic yet safely controlled settings for practising complex operations, which would be difficult or impossible to recreate physically due to costs or safety concerns.

This paper reviews how these simulated environments can be tailored to meet diverse learning needs and styles, offering more personalized training options. By adapting the level of difficulty and the feedback in real-time based on the learner's performance, VR and XR can offer a more effective learning experience compared to one-size-fits-all training approaches.

Moreover, the immersive nature of VR and XR can lead to higher levels of engagement and retention of information. This is crucial in professional fields where mastering complex skills is essential and can be enhanced significantly through repeated practice in lifelike settings (Petre et al., 2023).

In addition to these educational benefits, the paper will discuss the broader implications of VR and XR technologies in training and development, including their potential to reduce costs associated with physical training materials and facilities, and how they can make high-quality training more accessible to a wider audience.

In the following sections, we will detail the methodology used to examine the current applications of VR and XR in training, present the results from recent studies, and discuss the potential future developments in this area.

2. VR training paradigms

VR training is a novel way of teaching which provides a level of immersion that traditional teaching methods can not. This is achieved by creating a realistic digital environment where learners can interact with objects and observe events using a VR headset and motion controllers. Additionally, this type of training can further incorporate technologies such as haptic gloves and vests or omnidirectional treadmills, adding an extra layer of immersion. Using VR technologies makes it possible to recreate real-life conditions that may otherwise be either too costly to replicate on a large scale or too dangerous to expose learners to. Furthermore, a digital environment can be used to recreate high-stakes scenarios such as surgeries or firefighting scenarios without any real-world consequences.

Traditional learning can be either pen-and-paper teaching or instructor-based teaching. Both these methods are widely used in educational training and produce theoretical knowledge through interactions with an instructor or with various teaching materials. In contrast to VR training, traditional learning lacks in several areas. First of all, these learning techniques are unable to replicate the level of realism that VR can. Furthermore, due to the nature of pen-and-paper teaching, there is little to no interactivity with the subject matter, it being more focused on theoretical knowledge (Biggs, 1999). By contrast, instructor-led training provides some level of interactivity provided the instructor is knowledgeable on the subject matter (Salas et al., 2005).

VR training can be broken down into three categories: non-immersive VR training, semi-immersive VR training and fully immersive VR training. In non-immersive VR training learners are taught using traditional displays such as desktop screens and interact with the virtual environment using traditional input methods like keyboard and mouse. While not providing the same level of immersion as the other VR teaching methods, inhibiting the retention of information and lacking the practical experience, it is nonetheless more immersive than non-VR methods (Merchant et al., 2014). Since it does not require costly VR equipment, non-immersive teaching methods have some inherent advantages. Not requiring specialised equipment drastically brings down the costs associated with it, in turn making it easier to adopt as a teaching method.

Semi-immersive VR training is a step up from non-immersive training, utilizing multiple screens or large projectors to simulate an environment. Similar to non-immersive methods, there is no need for VR headsets to be set up however, depending on the subject matter being taught, the cost of screens or projectors can be higher (Issenberg et al., 2005).

Fully immersive training creates the most realistic and immersive VR experience. It utilises VR headsets and motion controllers, allowing the learner to fully interact with a digital environment. The high realism of VR training applications mirrors real-world scenarios and is the best for training in high-risk or enhanced stress fields such as medicine (Seymour et al., 2002). However, it is a somewhat limited method as its high setup cost can impede its wide adoption. Moreover, due to said high cost, it has a scalability problem, setting it up for a large group and having it be an efficient training tool being limited by the cost and larger area required to operate it. Lastly, retention is conditioned on the learner being comfortable with wearing VR headsets. Some users may experience discomfort from motion sickness after prolonged use, so it's not an effective teaching tool for everyone.

VR training can be further broken down in the way the training is achieved. All theme methodologies serve different purposes and have a wide spectrum of objectives and learning outcomes. Scenario-based learning immerses trainees in an environment in which they must respond to challenges in real-time (Herrera, Bailenson, Weisz, Ogle, & Zaki, 2018). This method of training allows for repeat training of the same person without real-world consequences (Cumin et al., 2013), improving decision-making and situational awareness (Pottle, 2019).

In contrast to scenario-based training in which a hard skill is developed and enforced, soft skills such as communication and management can be learned through role-playing scenarios. Doing this in a realistic digital environment can be a safe space for people to practice difficult conversations (Slater & Sanchez-Vives, 2019). It can be more engaging than an offline role-playing exercise. However, one drawback is that it is more difficult to evaluate one's skill as soft skills are prone to be highly subjective (Kothgassner et al., 2021).

If the objective is to teach a specific task, then the appropriate methodology is a task-oriented approach to teaching. This involves mechanical repetition of a specific task or group of tasks, ensuring skill retention through practice (Seymour et al., 2002). It is the best way to navigate hazardous courses, providing a safe space for the application of knowledge. It is however incompatible with a dynamic environment in which unpredictable variables can alter the scenario, being contextually inflexible (Cook et al., 2011).

Lastly, data-driven training uses AI algorithms and data analysis to alter the simulation, providing a dynamic training environment that is personalised to the learner's performance. Personalised learning can track patterns in learning and improve skill acquisition by constantly adapting to the student's needs (Makransky & Lilleholt, 2018). Moreover, generative AI technologies can accommodate students with learning disabilities or other special needs (Barbu et al., , 2025).

3. Applications of VR in training

Due to the benefits mentioned in previous chapters, numerous industries have chosen to implement VR training, including Medicine (surgeries, patient interaction, interactive learning environment), Phobia Treatment, Industrial Engineering-manufacturing, Aviation, First Aid Services (Ambulance), and Security Forces (Police, Military).

- **Medicine.** Following the COVID-19 pandemic, the lack of practical education among students in this field became evident. Studies on how students perceive information through VR applications have shown that the time required to learn the same information using traditional methods was cut in half (Barsom, Graafland & Schijven, 2016). Out of 177 students who participated in a case study (Wish-Baratz et al., 2020), 143 (81%) stated that VR-based learning offers more benefits. The main application studied was human body dissection. An example is the Dissection Master XR application, which uses photogrammetry-generated human body models. Users can view bodies at different stages of dissection and access information about body components by selecting them.
- **Phobia Treatment.** The primary treatment is in vivo exposure therapy, a form of cognitive-behavioural therapy based on the idea that unrealistic thoughts cause negative states and unpleasant behaviours. In each 60–90 minute session, the patient is exposed to a high-stress stimulus until the anxiety decreases (Freitas et al., 2021). VR Exposure Therapy allows patients to confront their fears in a virtual environment, with scenarios adapted to their progress. A study on a group of 10-15-

year-old children exposed to VR therapy for social phobia showed positive results. They participated in two scenarios: the schoolyard and the classroom, both with two difficulty levels: easy and hard (Gutiérrez-Maldonado et al., 2009).

- **Industrial Engineering.** This field depends on time and space, and the integration of other sciences has evolved with technological advancements. Implementing VR training aligns with the industry's goal of reducing resource consumption. A study conducted in Poland (Stecula, 2023) simulated a factory's production line change. Each step was accompanied by visual and audio cues — participants received voice commands with subtitles, and important process elements were highlighted in different colours. Additionally, task order and execution could be modified. VR training eliminates the need to halt production for personnel training, supporting efficiency. Moreover, VR allows multiple employees to be trained simultaneously in a safe environment compared to traditional methods.
- **Aviation.** A 1977 study conducted in the United States (Kocian, 1977) highlighted the need for flight simulators due to a reduction in pilot training hours caused by aircraft complexity, high operational costs, and funding limitations. Today, VR training resolves these issues by providing accurate depth perception, a 360-degree field of view, and multiple training modes, unlike older simulators. While past training simulators focused solely on piloting, modern VR simulators incorporate emergencies for pilots, flight attendants, and maintenance personnel. Additionally, training is monitored by an instructor, and students receive feedback on their performance.
- **Paramedics Training.** In 2018, a first aid training scenario was developed in the Czech Republic in collaboration with neighbouring countries to train ambulance personnel using VR for START (Simple Triage and Rapid Treatment) and METHANE (accident reporting via radio) methods in mass casualty incidents (Lochmannová et al., 2022). The VR training consists of multiple modules, each with different difficulty levels. The presence of visual and auditory stimuli enhances user experience, requiring participants to prioritize patients and apply medical procedures correctly. The scenario allows user freedom, with their actions influencing the situation's outcome.

4. Commonly used technologies in VR training

While discussing the various technologies employed in VR training, it is crucial to consider not only the immersive capabilities but also the security measures necessary to protect these digital environments. As highlighted by Zamfir et al. (2024), ensuring cyber resilience is essential, particularly in settings like virtual classrooms where sensitive information and user data are prevalent. Their guide provides comprehensive strategies for securing virtual classrooms against potential cyber threats, which is vital for maintaining trust and integrity in VR training systems.

HMD (Head Mounted Displays) are the primary equipment for enabling Virtual reality immersiveness. These are wearable devices designed to deliver immersive visual and auditory experiences by positioning screens or optical systems close to the user's eyes. These devices are commonly used in virtual reality (VR), augmented reality (AR), and mixed reality (MR) applications, offering environments where users can interact with virtual content in real-time. There are different types of HMD, including:

- Tethered Headsets: These headsets, which offer high-end performance and graphics, are connected to a workstation (Console, PC, etc.). Examples include the Oculus Rift, HTC Vive, and PlayStation VR.
- Wireless Headset: These headsets are all-in-one devices that do not require a workstation. They feature a built-in CPU, display, and sensors. Examples include the Oculus Quest and Pico Neo. Some headsets require connecting a smartphone that acts as a display and CPU, while the headset provides the lenses and device support. Examples of such headsets are Google Cardboard and Samsung Gear VR.

Immersive VR equipment brings VR immersiveness to a higher level, allowing users to experience fully immersive virtual reality. This is achieved by using advanced hardware designed to enhance the realism and interactivity of virtual reality experiences by providing users with greater freedom of movement and tactile feedback:

- ODT (Omnidirectional treadmill) is a mechanical device that allows a user to perform locomotive motion in any direction. It will enable 360-degree movements such as walking, running, or crouching. For safety, it provides a low-friction surface and harness system.
- Wired Gloves contain sensors that capture hand movement and interaction data such as finger bending or activating a switch. Advanced wired gloves can provide haptic feedback that renders the feeling of realistic button clicks, vibrations, and impact simulations. Users can feel virtual objects' texture, shape, or resistance through vibration or force actuators.
- Motion capture suits are wearable devices that track the user's entire body movement to provide accurate avatars in virtual spaces. Like haptic gloves, these suits also provide haptic feedback, simulating impacts, temperature, or pressure for a more immersive physical experience.
- Tracking devices are specialized hardware or integrated systems designed to capture and interpret the movement of facial features and

eye movements in real-time. These devices use high-resolution cameras, infrared sensors, or depth-sensing technology. High-end HMDs integrate such sensors, allowing the monitoring of key facial points, such as the movement of the eyes, reflections from the cornea and pupil, eyebrows, lips, and jaw.

A game engine is a comprehensive software framework designed to streamline and facilitate the development of video games by providing essential tools and functionalities. These engines typically include a rendering engine for graphics, a physics engine for simulating realistic movements and interactions, audio processing systems, scripting capabilities, and asset management tools. Modern game engines like Unity, Unreal or GoDot often support both 2D and 3D game development with advanced features like ray tracing, global illumination, and real-time graphics rendering. They also provide cross-platform compatibility, allowing developers to deploy games on multiple platforms such as PC, consoles, and mobile devices with minimal adjustments. Many engines include integrated development environments (IDEs) and support for programming languages like C#, C++, or Python, enabling developers to script gameplay mechanics and behaviours. Additionally, game engines are increasingly leveraging artificial intelligence and machine learning for adaptive gameplay, procedural content generation, and improved non-player character (NPC) behaviour.

CAD (Computer Aided Design) refers to the use of software tools to create, modify, analyze, and optimize designs in various fields, including engineering, architecture, and manufacturing. CAD systems facilitate the creation of precise 2D drawings, 3D models, and detailed blueprints by providing a digital workspace with specialized tools for geometry creation, dimensioning, and annotation. These tools allow users to construct complex shapes, surfaces, and assemblies with high accuracy, utilizing algorithms for geometric modelling, solid modelling, and parametric design. CAD software typically includes features like constraint management, which ensures that design changes adhere to specified parameters, and simulation capabilities, which can predict the performance and behaviour of designs under real-world conditions. Popular CAD platforms, such as AutoCAD, SolidWorks, and CATIA, offer integrations with CAM (Computer-Aided Manufacturing) and CAE (Computer-Aided Engineering) tools, creating an efficient design-to-production pipeline.

3D Modeling is the process of creating a 3D representation of an object, character, or environment using specialized software. It involves constructing a digital mesh, which is made up of vertices, edges, and polygons, that define the shape and structure of the model. There are various techniques used in 3D modelling, including polygonal modelling (building objects through connected polygons), sculpting (shaping models like virtual clay), procedural modelling (using algorithms and parameters to generate models and photogrammetry (capturing multiple overlapping images of a subject from different angles to generate an accurate 3D model). Modern 3D modeling software, such as Blender, Autodesk Maya, and 3ds Max, offers advanced tools for precision modelling, UV mapping for textures, and rigging for animation and tools like Agisoft Metashape, RealityCapture, Autodesk ReCap and Meshroom are commonly used in photogrammetry, offering robust features for refining, scaling, and exporting models. Photogrammetry also plays a significant role in geospatial analysis, where it is used in conjunction with drones or satellites for large-scale topographic mapping. Its efficiency, accuracy, and ability to capture fine details make it a powerful tool for creating high-quality 3D representations from real-world data.

5. Challenges of VR training

Like any other emergent technology, unavoidable challenges and disadvantages can be identified in VR.

There are several hardware limitations such as the cost of high-quality equipment like HMD, treadmills, powerful workstations and any other assets required to be fully immersed in the training scenario. Otherwise, VR training can provide limited haptic feedback in the absence of specialized VR hardware that can reduce the realism of tasks that rely on physical sensations. There is also a lack of standardization for different VR systems, hence, compatibility issues arise and it makes it challenging to create universal training programs. Another drawback is the HMD’s short battery life; especially if intensive training is conducted, the battery cannot sustain the HDM for more than one hour.

Developing VR training programs requires many resources, such as skilled developers, designers, and experts in the subject matter. To be effective, VR training must accurately simulate real-world conditions. Poorly designed simulations may lead to unrealistic expectations or improper training.

Users unfamiliar with VR may require time to adapt to the interface and controls, potentially slowing down training. Some users experience nausea or dizziness (VR sickness) due to latency issues, unnatural movement or prolonged exposure.

6. VR training user perception

Understanding user perception of Virtual Reality (VR) training is crucial for assessing its effectiveness and identifying areas for improvement. Techniques like those discussed by Văduva et al. (2023), which involve web scraping and natural language processing, can be instrumental in analyzing user feedback across various platforms to gauge overall satisfaction and pinpoint areas for technological refinement and user interface improvements.

6.1 User experience and immersion

One of the primary benefits of VR training is its ability to immerse users in realistic environments that enhance learning through practical experience.

Immersion can be evaluated through both subjective user feedback and objective measures such as increased heart rate or galvanic skin response during training sessions. Studies indicate that higher levels of immersion correlate with improved learning outcomes, as users are more engaged and can practice skills in a context that closely simulates real-life scenarios.

6.2 Usability of VR training systems

The usability of VR systems is another critical aspect of user perception. This includes the ease of navigating through the VR environment, the intuitiveness of the interface, and the physical comfort of using VR hardware. Poor usability can detract from the training experience, leading to frustration and decreased learning effectiveness. Feedback from users often highlights the need for more intuitive controls and ergonomic hardware designs to reduce physical strain and enhance the overall user experience.

6.3 Learning enhancement through VR

Perceptions of learning enhancement involve trainees' views on how effectively VR training supports skill acquisition and knowledge retention compared to traditional training methods. User feedback generally reflects a positive view, with many trainees reporting faster learning curves and better retention of information due to the interactive and engaging nature of VR training. However, the effectiveness can vary depending on the design of the training program and the specific learning objectives it aims to achieve.

6.4 Satisfaction and acceptance

Overall satisfaction with VR training is influenced by factors such as the realism of the simulations, the relevance of the skills practised to real-world applications, and the perceived value of the training in improving job performance. Acceptance of VR as a training tool also depends on cultural attitudes towards technology and individual openness to new learning methods. Surveys and interviews with trainees reveal a broad acceptance of VR training, particularly among younger and more technologically savvy users, though some reservations remain among those less familiar with VR technology.

6.5 Challenges and barriers

Despite the positive perceptions, some challenges and barriers affect user experience with VR training. These include physical discomfort, such as motion sickness, which can affect long-term usability and learning outcomes. Additionally, the high cost of VR equipment and the need for technical support are seen as barriers to widespread adoption, particularly in resource-constrained settings.

7. A conceptual framework for VR training

In this section, we propose a conceptual framework for a fully immersive VR application that combines multiple aspects of the teaching methodologies outlined in section 2. This training simulation is aimed at training personnel on how to deal with multiple potentially dangerous situations without prior knowledge of the scenario they're going to be presented with. This would test their knowledge of the safety protocols, their decision-making under pressure and their reaction speed to a developing situation, as well as the efficacy of the protocols and procedures put in place for the said situations. The basic outline of this application is detailed in Figure 1.

The minimum hardware requirements for this training suite are one workstation powerful enough to run two applications at once, one wireless HDM and one ODT. The HDM must be wireless, as a wired one would be a safety hazard, as the wire could easily wrap itself around someone's neck. The workstation has to run two applications simultaneously: the simulation and the control panel from which the simulation is being controlled. Outside the learner, there also need to be 2 extra people to ensure the smooth operation of the training process. The first one is the operator, who controls the simulation by altering variables based on the performance of the learner and who can also see what's going on within the simulation i.e. can see what the learner is doing and the supervisor who ensures the safety outside the simulation, helps the learner get in and out of the ODT and makes sure everything is running smoothly.

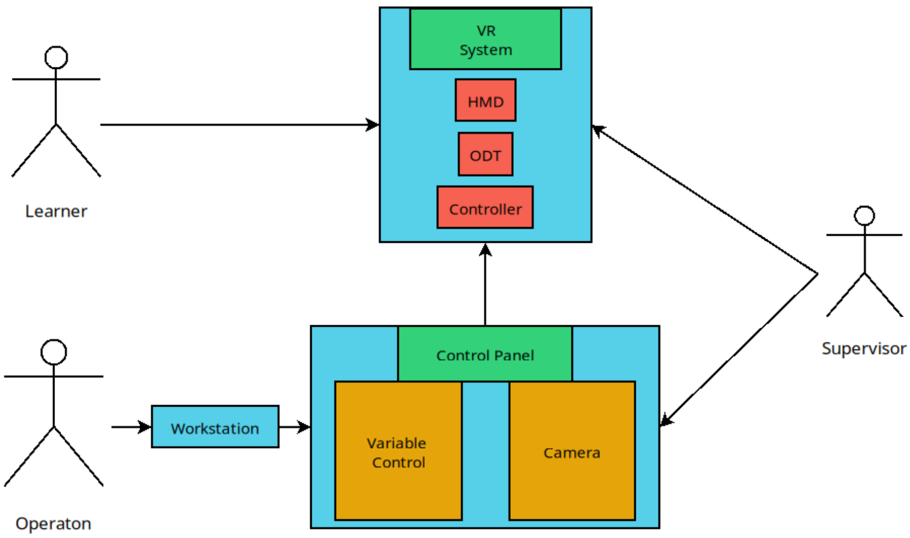

Figure 1. General workflow of all components of the conceptual framework.
Source: own research

The control panel is an essential component of the training simulation as it can activate different scenarios based on user experience, and manipulate certain environment objects and triggers. This program can also function as a stream listener, showing various parts of the scenario, functioning like a video surveillance system where the operator can examine the current training progress and freely adjust the scenario, as well as give verbal indications should the need arise.

With this conceptual framework, we aim to combine three different teaching methodologies. First, it is a scenario-based simulation, as it tests the decision-making abilities of the trainee under pressure in a given emergency scenario. It is also a task-oriented approach as it is within the realm of possibility that the operator can decide to repeat the scenario multiple times over, encouraging the development of muscle memory in these scenarios. Lastly, the simulation can be altered in real-time based on prior performance, personalizing it for the trainee.

8. Conclusion

User perception of VR training is generally positive, with notable benefits in immersion, learning enhancement, and user satisfaction. However, to maximise VR's potential in training environments, ongoing challenges related to usability, physical comfort, and accessibility must be addressed. As technology advances and more user feedback is integrated into VR training systems, these tools will likely become even more effective and widely accepted in professional training programs.

VR training developers have to take into account several costs that come associated with this teaching method when projecting their domain-specific application. This not only includes the tangibles such as equipment cost, physical space available and the processing power needed to run their software, but also intangibles namely user safety, comfort, disability support and a a clear definition as to who and what the training is designed for. Our proposed framework incorporates multiple aspects of different training applications, making it easy to mould to any requirements.

REFERENCES

Barbu, M., Iordache, D.-D., Petre. I., Barbu, D.-C., Băjenaru, L. (2025) Framework Design for Reinforcing the Potential of XR Technologies in Transforming Inclusive Education. *Applied Sciences*. 15(3):1484. doi: 10.3390/app15031484.

Barsom, E. Z., Graafland, M. & Schijven, M. P. (2016) Systematic review on the effectiveness of augmented reality applications in medical training. *Surgical Endoscopy*. 30(10), 4174-4183. doi: 10.1007/s00464-016-4800-6 .

Biggs, J. B. (1999) *Teaching for Quality Learning at University*. Buckingham: Open University Press.

Cook, D. A., Hatala, R., Brydges, R., Zendejas, B., Szostek, J. H., Wang, A. T., Erwin, P. J. & Hamstra, S. J. (2011) Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. *JAMA*. 306(9), 978–988. Doi:10.1001/jama.2011.1234.

Cumin, D., Boyd, M. J., Webster, C. S. & Weller, J. M. (2013) A systematic review of simulation for multidisciplinary team training in operating rooms. Simulation in healthcare. *Journal of the Society for Simulation in Healthcare*. 8(3), 171–179. doi: 10.1097/SIH.0b013e31827e2f4c.

Freitas, R., Velosa, V. H. S., Abreu, L. T. N. & Jardim, R. L. (2021) Virtual Reality Exposure Treatment in Phobias: A Systematic Review. *Psychiatric Quarterly*. 92(4), 1-26. doi: 10.1007/s11126-021-09935-6.

Gutiérrez-Maldonado, J., Magallón-Neri, E., Rus-Calafell, M. & Peñaloza, C. (2009) Virtual reality exposure therapy for school phobia. *Anuario de Psicología / The UB Journal of Psychology*. 40(2), 223-236. https://www.researchgate.net/publication/228745286_Virtual_reality_exposure_therapy_for_school_phobia [Accessed 24th February 2025]

Herrera, F., Bailenson, J., Weisz, E., Ogle, E. & Zaki, J. (2018) Building long-term empathy: A large-scale comparison of traditional and virtual reality perspective-taking. *PloS one*. 13(10), e0204494. doi: 10.1371/journal.pone.0204494.

Issenberg, S. B., McGaghie, W. C., Petrusa, E. R., Lee Gordon, D. & Scalese, R. J. (2005) Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Medical teacher*. 27(1), 10–28. doi: 10.1080/01421590500046924.

Kocian, D. F. (1977) A Visually-Coupled Airborne Systems Simulator (VCASS) - An Approach to Visual Simulation. 6570. *Aerospace Medical Research Laboratory*. https://apps.dtic.mil/sti/citations/ADA039999 [Accessed 24th February 2025]

Kyrlitsias, C. & Michael-Grigoriou, D. (2022) Social Interaction with Agents and Avatars in Immersive Virtual Environments: A Survey. *Frontiers in Virtual Reality*. doi: 10.3389/frvir.2021.786665.

Lochmannová, A., Šimon, M., Hořejší, P., Bárdy, M., Reichertová, S. & Gillernová, K. (2022) The Use of Virtual Reality in Training Paramedics for a Mass Casualty Incident. *Applied Sciences*. 12(22), 11740. doi: 10.3390/app122211740.

Makransky, G. & Lilleholt, L. (2018) A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development*. 66(5), 1141–1164. doi: 10.1007/s11423-018-9581-2.

Merchant, Z., Goetz, E.T., Cifuentes, L., Keeney-Kennicutt, W. & Davis, T.J. (2014) Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*. 70, 29–40. doi: 10.1016/j.compedu.2013.07.033

Petre, I., Iordache, D., Zamfir, M., Barbu, M., Duţescu, R. & Marinescu, I.A., (2023) Virtual worlds, real technologies: an insight into Metaverse and its principles. *24th International Conference on Control Systems and Computer Science (CSCS), Bucharest, Romania, 2023*. pp. 551-556, doi: 10.1109/CSCS59211.2023.00093.

Pottle, J. (2019) Virtual reality and the transformation of medical education. *Future Healthcare Journal*. 6(3), 181–185. doi: 10.7861/fhj.2019-0036.

Salas, E., Wilson, K. A., Burke, C. S. & Priest, H. A. (2005) Using simulation-based training to improve patient safety: What does it take? *Joint Commission Journal on Quality and Patient Safety*. 31(7), 363–371. doi: 10.1016/s1553-7250(05)31049-4.

Seymour, N. E., Gallagher, A. G., Roman, S. A., O'Brien, M. K., Bansal, V. K., Andersen, D. K. & Satava, R. M. (2002) Virtual reality training improves operating room performance. *Annals of Surgery*. 236(4), 458–464. doi: 10.1097/00000658-200210000-00008.

Slater, M. & Sanchez-Vives, M.V. (2016) Enhancing our lives with immersive virtual reality. *Frontiers in Robotics and AI*. 3(74), 1–18. doi: 10.3389/frobt.2016.00074.

Stecula, K. (2023) Review of Virtual Reality Applications Applied in Industrial Practice. *Scientific Papers of Silesian University of Technology Organization and Management Series.* 2023(187). doi: 10.29119/1641-3466.2023.187.32.

Văduva, A.-G., Oprea, S.-V., Barbu, D.-C. (2023) Understanding Customers' Opinion using Web Scraping and Natural Language Processing. *Ovidius University Annals Economic Sciences Series Volume XXIII.* 1, 537-544. https://ibn.idsi.md/sites/default/files/j_nr_file/Full%20Vol.%20XXIII%20Issue%201%202023.pdf. [Accessed 24th February 2025].

Wish-Baratz, S., Crofton, A. R., Gutierrez, J., Henninger, E. & Griswold, M. A. (2020) Assessment of Mixed-Reality Technology Use in Remote Online Anatomy Education. *JAMA Netw Open.* 3(9), e2016271. https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2770727.

Zamfir, M., Barbu, M., Marinescu, I.A., Iordache, D. & Cîrnu, C. (2024) Ensuring Cyber Resilience: A Thorough Guide to Securing Virtual Classrooms. *32nd Euromicro International Conference on Parallel, Distributed and Network-Based Processing (PDP), Dublin, Ireland, 2024*. pp. 167-174, doi: 10.1109/PDP62718.2024.00031.