Training registry of the Modern Business Services sector

Project Reference Number: 101132877

Workshop Title: VR in the Learning Process

Author: Syntea S.A.

Poland

Co-funded by the European Union

Disclaimer: This project is funded by the European Union. The views and opinions expressed are solely those of the author(s) and do not necessarily reflect those of the European Union or EACEA. Neither the European Union nor the granting authority can be held responsible for them.

Co-funded by the European Union

Contents

Co-funded by the European Union

Title	VR in the Learning Process
Workshop Content	Through this workshop, learners will learn about: 1. The history of VR Technology 2. VR/AR/MR/XR definitions and platforms 3. What 'is' and what 'is not' VR technology 4. The basics of VR Technology 5. Types of VR Platforms 6. Market offer and selection of hardware to meet training needs 7. Standard elements of HMD Kits 8. Principles of safe use of HMD Kits 9. Setup, Security Systems and Gameplay 10. Principles of Operation and Elements of OS and UI and Navigation with indicators 11. Alternative User Tracking Options and Peripherals 12. Options for steaming content from VR Goggles for training purposes 13. Implementation of Training Process using VR Tools 14. Maintenance, Cleaning, Charging, Battery Replacement, Transportation and Storage
Learning Outcomes	1. Launch, parameterize and adapt VR tools to the recipient of the training process. 2. Operate the VR device correctly and take into account the principles of safe use. 3. Operate VR software functionality, including basic operating system functions (UI, security systems, user accounts, user tracking). 4. Navigate the virtual environment, taking into account manipulation with pointers and various forms of locomotion (6DOF user tracking, locomotion with manipulator functions). 5. Implement the training process using VR tools, taking into account group work in a virtual environment.

Co-funded by the European Union

1. Introduction

We are living through a time of profound technological transformation—one that is reshaping not only the nature of work but also the way we prepare individuals for it. In this shifting landscape, immersive technologies such as Virtual Reality (VR) are playing an increasingly central role in vocational training, workforce development, and education. No longer the domain of gaming or science fiction, VR has matured into a robust, evidence-based tool for delivering engaging, repeatable, and measurable training experiences. Backed by a growing corpus of research (Kavanagh et al., 2017; Lege and Bonner, 2020; Dubovik, 2024), immersive learning is being implemented across a wide spectrum of industries—from healthcare and hospitality to construction, logistics, and advanced manufacturing.

This document serves as a comprehensive guide to the integration of VR into educational and training contexts. It is structured to support instructors, training managers, instructional designers, and technology coordinators who are either beginning their journey into immersive training or seeking to expand and formalize its application within their organizations. Each chapter has been carefully developed to align with practical requirements, theoretical insights, and long-term sustainability goals.

We begin by tracing the historical development of VR technology, starting from its conceptual roots in the 1960s and evolving through military simulations, industrial applications, and the rise of consumer-grade systems in the 2010s. Understanding this evolution is crucial for contextualizing current tools and anticipating future developments. Next, the module demystifies the related concepts of VR, AR (Augmented Reality), MR (Mixed Reality), and XR (Extended Reality), offering clear definitions and practical distinctions that help in choosing the right technology for specific training outcomes.

The core chapters focus on the hardware and software ecosystem that supports immersive learning. These include guidance on choosing appropriate VR platforms (e.g., PC-based vs. standalone systems), fitting and adjusting headsets, configuring training environments, and ensuring compliance with safety, hygiene, and accessibility standards. Emphasis is placed on user readiness, minimizing simulator sickness, and the importance of ergonomic considerations such as inter-pupillary distance, controller design, and tracking fidelity.

As training environments become more complex, the need to integrate extended capabilities—such as haptic feedback systems, eye tracking, and external peripherals—also grows. This guide provides practical information on how such technologies can enrich learning scenarios,

Co-funded by the European Union

improve fidelity, and offer more nuanced feedback mechanisms. A dedicated section on streaming and broadcasting tools ensures that instructors can observe, evaluate, and support learners in real time, even across distributed training setups.

Perhaps most importantly, the module takes a pedagogically grounded approach to VR implementation. It explores how to design immersive modules around specific, measurable learning outcomes and how to structure them into learning sets that reflect the building blocks of professional qualifications. Assessment strategies, feedback loops, and performance tracking tools are reviewed to help training providers demonstrate impact and effectiveness—key requirements in both educational quality assurance and industry certification contexts.

The final chapters address long-term sustainability. Implementing VR in training is not just about acquisition—it requires maintenance protocols, battery and hygiene management, storage logistics, and periodic system updates. The guide also introduces administrative best practices for deployment, content lifecycle management, and technical troubleshooting.

Co-funded by
the European Union

2. Foundations of VR Technology

2. a. History of VR

The origins of Virtual Reality (VR) trace back much further than the sleek and lightweight devices seen today. In 1968, Ivan Sutherland, a pioneer in computer graphics, and his student Bob Sproull developed the “Sword of Damocles,” the first head-mounted display (HMD). Though it rendered only basic wireframe images and had to be suspended from the ceiling, it introduced the core concept of immersive, computer-generated environments.

Throughout the 1980s and 1990s, VR technology progressed from academic experiments to applied tools in both military and entertainment contexts. Organizations such as NASA and the U.S. military utilized VR for flight simulation and teleoperation, while private companies like VPL Research introduced early consumer-accessible peripherals such as data gloves and rudimentary headsets.

The early 2010s marked the resurgence of VR in the public sphere, catalyzed by the Oculus Rift prototype, which attracted mainstream attention and was later acquired by Facebook (now Meta). This innovation sparked the development of modern VR platforms—portable, high-resolution, and capable of real-time motion tracking—ushering in a new era of immersive technology.

Today, VR and its broader category of Extended Reality (XR), which includes Augmented Reality (AR) and Mixed Reality (MR), are increasingly integrated into training, education, and professional development across multiple sectors, including construction, healthcare, logistics, and service industries. These technologies now offer scalable, user-friendly, and effective solutions for immersive learning.

2. b. Understanding Immersive Technologies

The term "immersive technologies" encompasses a spectrum of digital tools designed to simulate or augment reality. These include:

- **Virtual Reality (VR)**: A fully immersive experience that replaces the physical environment with a computer-generated one. Users typically wear head-mounted displays (HMDs) that respond to head and body movement, allowing them to interact with 3D virtual spaces.
- **Augmented Reality (AR)**: Overlays digital elements—such as labels, animations, or real-time information—onto the real-world view. Commonly experienced via smartphones or tablets, AR does not replace the user's environment but enhances it.

Co-funded by the European Union

- **Mixed Reality (MR)**: Integrates virtual and physical environments in a way that allows interaction between real and digital objects. For instance, a virtual panel anchored to a real desk that responds to the user's gestures.
- **Extended Reality (XR)**: An umbrella term that covers VR, AR, and MR, reflecting the full range of immersive experiences made possible by emerging technologies.

These technologies vary in their levels of immersion and application. For example, AR is ideal for on-site support or live data overlays, while VR is better suited for high-risk simulations or complete scenario-based training. MR combines both approaches and is especially valuable for interactive tasks involving spatial awareness and precision.

2. c. What Is and What Is Not VR

As the popularity of immersive technologies grows, so do misconceptions about what constitutes Virtual Reality. It is essential to distinguish genuine VR from adjacent digital experiences.

VR is not:

- A 360-degree video experience viewed on a flat screen.
- A simple 3D simulation that does not respond to user movement.
- Any experience that lacks head-tracked, real-time rendering in a three-dimensional space.

VR is:

- A fully immersive environment where users can interact with and navigate within a 3D digital space using headsets and motion controllers.
- An experience that responds dynamically to the user's physical movement, including head orientation and, in many cases, hand or full-body tracking.
- A platform that isolates the user visually and aurally from the real world, enhancing the sensation of presence or "being there."

Understanding these distinctions ensures appropriate use of VR in educational and training environments, avoiding the mislabeling of tools that do not offer true immersion or interaction.

2. d. How Does It Work?

At the center of any VR system is the HMD—the Head Mounted Display. This is a wearable device (commonly referred to as VR goggles) that fully immerses the user in a virtual environment.

Co-funded by the European Union

The HMD tracks head movements and sometimes even body position, displaying realistic 3D imagery and spatial sound that reacts to the user's movements.

Modern VR systems can operate in two major modes:

- **PC VR**: Requires a powerful computer and is suitable for graphically intensive simulations.
- **Standalone VR**: Independent, wireless headsets like Meta Quest—ideal for classrooms or workshops due to their portability and ease of use.

Figure 1. HMD (Oculus MetaQuest 3) connected via USB to external power source as a precaution from the battery running low.

For a training room setup, **standalone VR systems** are optimal. They reduce technical complexity and support scalable group instruction. These systems typically include a “guardian” boundary or safety zone that must be defined clearly within the physical space. This prevents users from colliding with real-world objects while immersed in virtual tasks.

Co-funded by the European Union

2. e. Immersion and Realism

Immersion is a term used to describe how deeply a person feels “present” inside the virtual world. There are three key technologies here, each with increasing levels of immersion:

1. **AR (Augmented Reality)** overlays digital elements (like a face filter or instruction labels) onto the real world.
2. **MR (Mixed Reality)** blends physical and digital elements, letting users interact with 3D objects anchored in real space (e.g., a holographic control panel).
3. **VR (Virtual Reality)** offers full immersion by placing the user in an entirely virtual environment.

This scale matters in training design. For example, a chef-in-training might use AR to see virtual cooking instructions on a real cutting board. In VR, that same chef could safely simulate handling knives, ovens, and timing tasks in a virtual kitchen.

2. f. Motion and Locomotion in Virtual Spaces

One critical consideration in VR training is locomotion—how a user moves within the virtual world. The safest and most comfortable method is natural tracking (6 Degrees of Freedom), which mirrors the user’s real-world movement. Next is teleportation, where users click to "jump" to a new location. Most invasive is controller-based movement (joystick navigation), which most influences the chance for the simulator sickness symptoms to occur—a type of motion sickness caused by a mismatch between visual motion and physical stillness.

Co-funded by the European Union

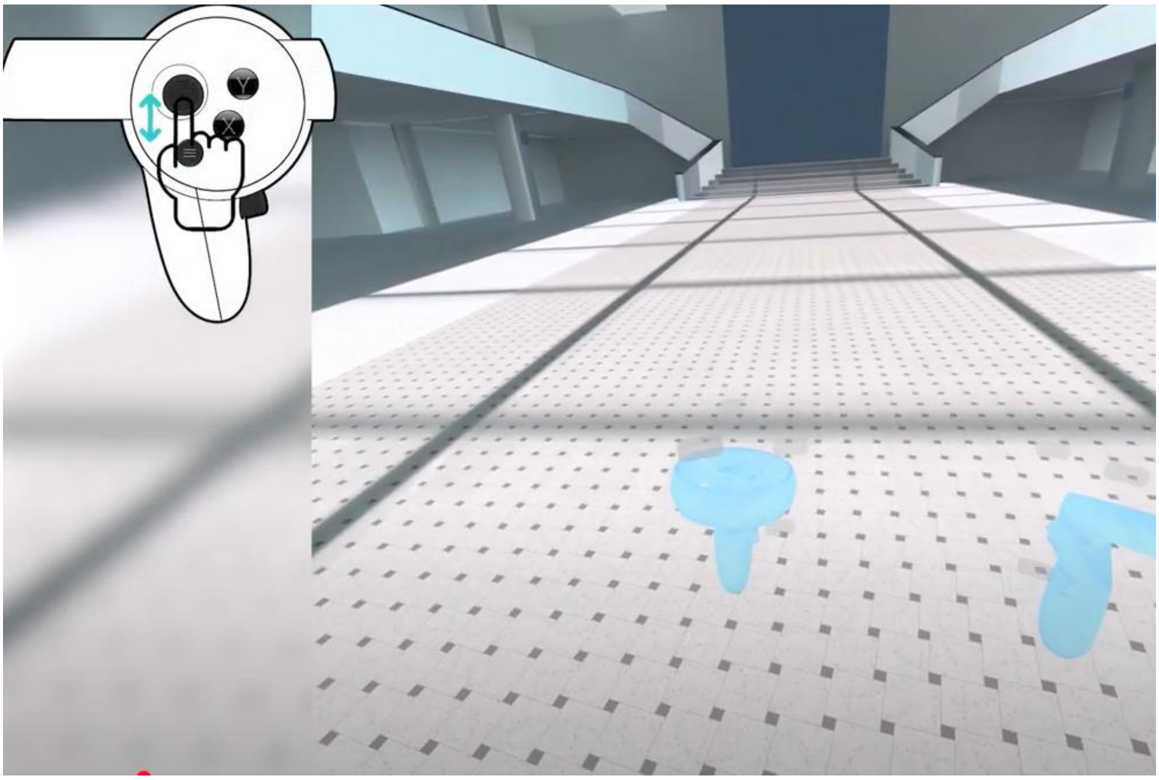

Figure 2. Left-hand controller has a joystick which can be used for movement when space is limited.

Simulator sickness isn't universal. Some users never experience it, while others may feel dizzy or nauseous even after a short period of use. Fortunately, tolerance tends to improve with exposure. The key is to gradually introduce learners to VR and select low-invasiveness locomotion methods first.

2. g. Cognitive and Physical Considerations

Before implementing VR training, it's essential to understand contraindications. While VR is broadly accessible, it may not be suitable in some situations. You should not use a VR device if any of the following occur due to increased susceptibility to adverse symptoms.

- Fatigue or exhaustion,
- Drowsiness,
- Being under the influence of alcohol or narcotics,
- Alcohol poisoning,
- Nausea or a problem with the digestive system,
- Anxiety or stress,
- Cold, flu, headache, migraine, earache.

Co-funded by the European Union

A special place among the contraindications to VR use is **epilepsy**. Some people may experience dizziness, eyelid or muscle twitching, or seizures caused by flickering lights or sequences of lights. This can occur even in situations where these individuals have never experienced epilepsy or seizures before and have not been diagnosed with such health problems (latent disease). Although the chances of this type of affliction are minimal (about 1 in 4,000 people), anyone experiencing comparable symptoms should stop using the device immediately and consult a doctor at the first opportunity.

Mobility disabilities, such as the use of a wheelchair, **do not disqualify learners** from VR use—provided that the VR experience is designed with these needs in mind. Many VR systems can calibrate to seated height, and hand controls can substitute for walking. In fact, VR devices have the ability to calibrate the gameplay area in stationary mode (eliminating the need to move around in the real world), and the locomotion with manipulators creates great opportunities for people with mobility disabilities to experience their surroundings in completely differet way.

Likewise, users who wear **corrective glasses** can comfortably use most modern headsets, which are designed to accommodate eyewear - either through the use of spacer inserts or through the ability to install corrective lenses directly into the headset's eyepieces. Some models also include **IPD (Inter-Pupillary Distance)** adjustments—allowing users to fine-tune the spacing between lenses for clarity and comfort, providing a good user experience for people with different eye spacing.

2. h. Environmental and Age Guidelines

Proper lighting is essential for **inside-out tracking** used in most standalone headsets. Issues may arise:

- In **dimly lit** rooms (tracking sensors struggle)
- In **extremely bright** settings (glare interferes with sensors)
- **Outdoors** (too much IR interference and direct sunlight can damage the optics of the set)

Therefore, training sessions should occur in evenly-lit, enclosed spaces.

For safety and developmental reasons, most VR manufacturers recommend headsets for users aged **12 or 13 and up**. Younger children may not have fully developed eye muscles to handle prolonged exposure to stereoscopic visuals. The goggles are not sized for children, and improper sizing

Co-funded by the European Union

of the device can result in discomfort or be detrimental to health - for example, by putting undue strain on the neck.

2.i. Mixed Reality and Its Interactive Power

Mixed Reality (MR) stands apart from VR in that it allows virtual objects to be anchored to real-world locations. For instance, a virtual instruction manual can appear on top of a real workbench and respond when the user gestures toward it. This makes MR especially powerful in technical skills training.

On the other hand, **AR** is used in applications like Instagram filters or smartphone games like Pokémon Go. These technologies don't require full immersion or a headset but can be enhanced by **smart glasses** or HMDs to offer more precision and depth.

Technologies like **VR, AR, MR**, and **XR** (the collective term) may use **special glasses or headsets** to enhance interaction, although AR can function without them.

Co-funded by the European Union

3. VR platforms and Ecosystems

3.a. Types of VR platforms

At the foundation of most applications lies a game engine, such as **Unity**, which facilitates the creation of 3D environments, animations, and physics simulations. Unity's built-in support for **XR (extended reality)** development makes it an ideal platform for building experiences that are compatible with a wide range of VR headsets, from **standalone devices** (e.g. Oculus MetaQuest) to tethered PC-based systems.

VR platforms are categorized based on the type of hardware and computing power they rely upon. Each category offers different advantages depending on the context of use, required performance, and available infrastructure.

- **PC-based VR:** These systems are tethered to a high-performance computer that handles intensive graphics rendering. Examples include HTC Vive Pro 2, Valve Index and Bigscreen Beyond 2. On the high-end side, there will be models such as the Primax or Varjo product lines. PC VR is best suited for environments that require high visual fidelity, such as advanced engineering simulations or surgical training. The trade-off is reduced mobility and more complex setup.
- **Standalone VR:** Devices like Meta Quest 2 or 3, PICO series or HTC Focus series function independently without requiring a computer or external sensors. They are lightweight, wireless, and highly portable, making them ideal for training environments where simplicity, safety, and flexibility are priorities. Though not as powerful as PC-based systems, standalone VR has improved rapidly in display quality, tracking, and battery life.

The choice of platform depends on training needs. High-precision, resource-intensive applications will favor PC VR, while general skill training, safety drills, or procedural learning can often be implemented effectively using standalone VR systems.

It should also be borne in mind that a key aspect of selecting the right platform should be the premises and logistical conditions. While the implementation of a specialized training process using a high-powered computer is an acceptable solution for dedicated training centers, it is practically inapplicable in the conditions of a standard classroom, especially for group teaching. The computer hardware to handle such a process is expensive and takes up a lot of space (we are talking about

Co-funded by the European Union

desktop computers). Tracking in such solutions is most often supported by external sensors, requiring proper spacing and parameterization, which requires specialized know-how. They are either mounted on walls or set up on tripods - in the first case it is not very flexible and problematic, in the second - requiring additional space. In addition, the trainee is at all times hooked up to the computer with a cable, which poses a danger to trainees (due to the possibility of tripping over stretched cables) and the risk of damaging the equipment.

With all the arguments in mind, standalone VR is a more optimal solution for training purposes in almost every case, and certainly for a group-implemented process in a classroom context. At the same time, it is worth noting that standalone VR headsets can be connected to a PC in order to use the computer's computing power for graphics rendering, so this approach does not close the door to enjoying the benefits and quality of experience provided by PC VR.

Users who access the system via **VR headsets** are afforded the most immersive experience. With full six degrees of freedom (6DoF) tracking, these users can look around, move within the space, and interact with virtual objects using motion controllers. They can manipulate objects, operate machinery, and receive tactile feedback through haptic-enabled devices. The fidelity of this interaction enhances spatial learning and physical coordination.

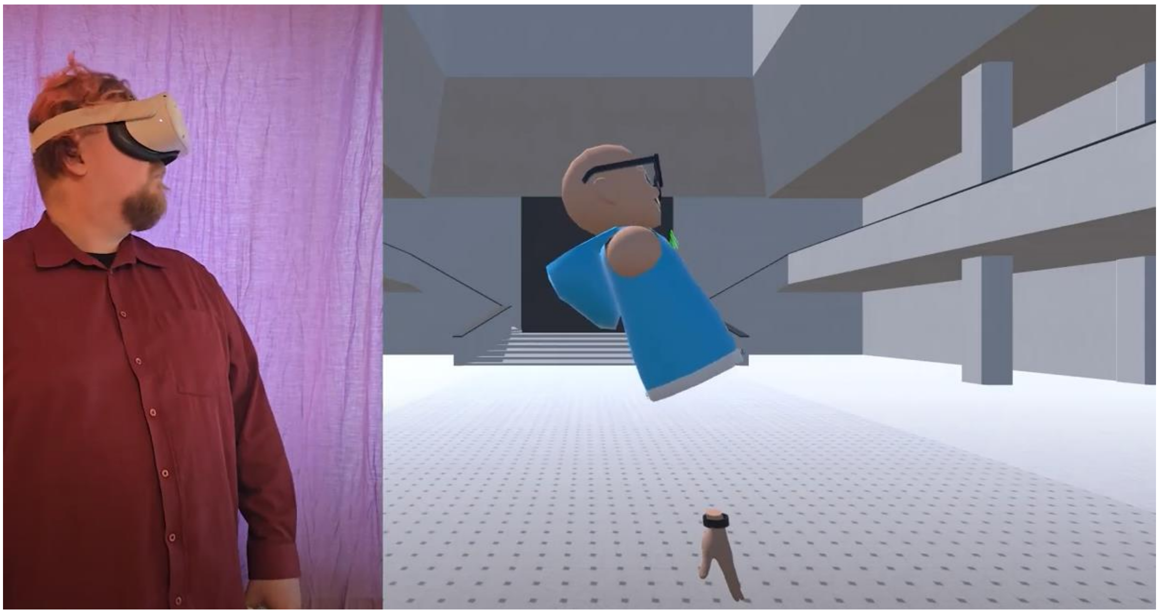

Figure 3. Virtual reality setting emulating real life movement and gestures

Desktop users, in contrast, navigate the virtual space using keyboard inputs for movement and a mouse for camera control and object interaction. This mode is less immersive but provides

Co-funded by the European Union

accessibility for users without VR hardware. It is suitable for scenarios that prioritize procedural understanding over physical manipulation. It is also very useful for a Trainer in order to monitor students' activity inside VR application.

Experimental navigation features - such as using a desktop application to explore a virtual world - create amazing circumstances for implementing training processes on a larger scale, such as in school teaching. Regardless of a teacher's predisposition toward VR, it's hard to imagine a person of productive age these days who can't operate a computer. This allows the teacher to control the process and share the simulation with his or her students, without having to put on a VR headset. In the context of the classroom, it is even advisable that the teacher does not completely cut himself off from the outside world, out of the rationale of the need to take care of his students.

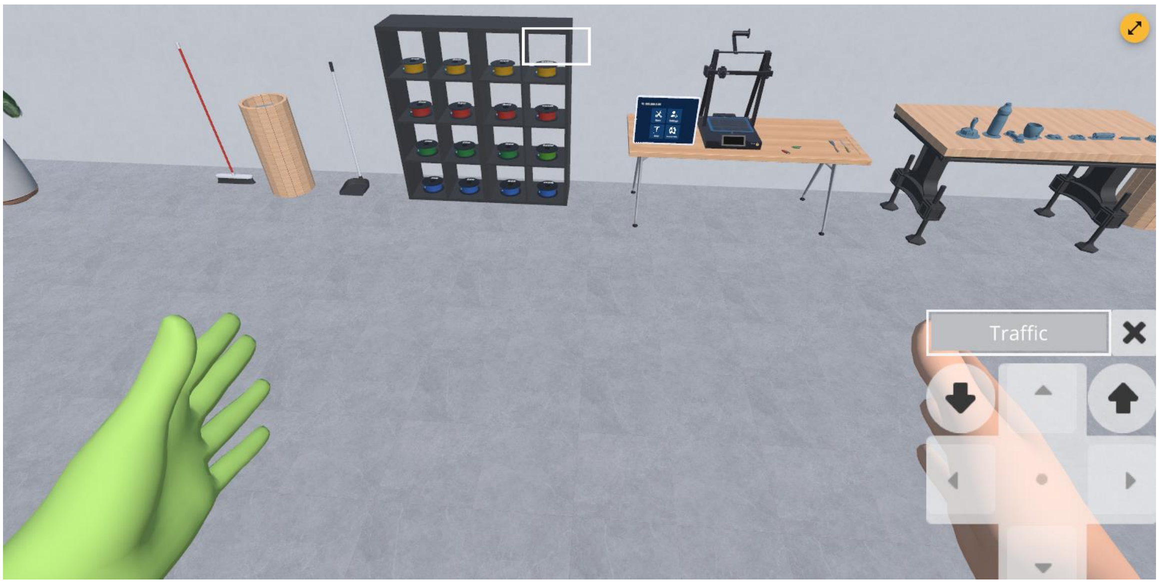

Figure 4. Desktop view corresponding 1:1 with the VR headset view. Movement and interactions are coming from keyboard input.

An equally experimental approach is the use of **mobile devices** in processes supported by VR solutions. As with desktop, mobile devices offer the possibility of an asymmetrical approach to the process, with some people participating in a simulation using VR headsets and some on a different type of device.

Mobile device users interact with simplified versions of the training content. Gestural inputs, like tapping and swiping, are used to navigate menus and trigger animations. These users often view pre-recorded simulations or interact with augmented elements in their physical space. Due to

Co-funded by the European Union

processing and interface limitations, mobile interaction is typically observational rather than manipulative.

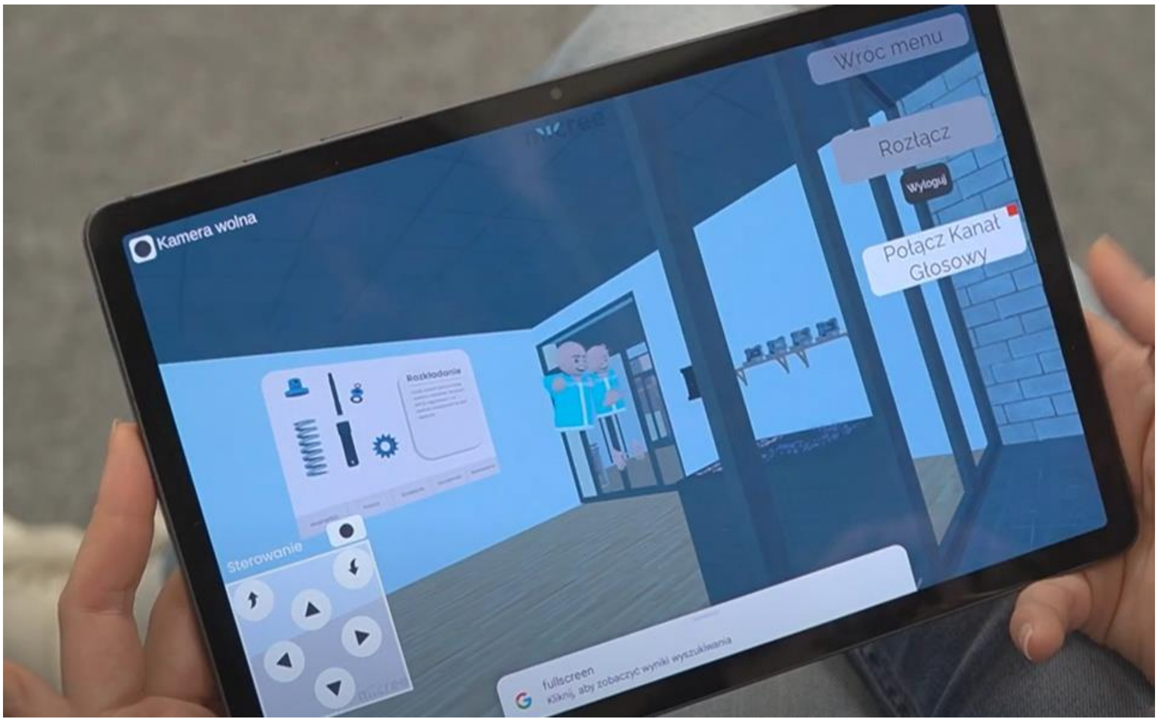

Figure 5. Mobile view corresponding 1:1 with the VR headset view. Movement and interactions are coming from touchscreen input.

The application must recognize these different user profiles and deliver tailored experiences. Developers should consider input abstraction layers and UI scaling to support consistent interaction regardless of device type.

3.b. Market overview and hardware selection

Selecting appropriate VR hardware is not merely a technical decision—it is a strategic choice that must be grounded in clearly defined training objectives and an understanding of the learners who will use it. The hardware must align with the nature of the skills being taught, the level of immersion required to achieve desired outcomes, and the characteristics of the physical environment in which training will take place.

Co-funded by the European Union

Several factors guide this selection. First, display resolution and refresh rate are critical. Higher resolution provides sharper, more realistic visuals, while a high refresh rate helps minimize latency and motion blur, significantly reducing the risk of simulator sickness—especially for novice users. A wider field of view contributes to a more natural and engaging user experience by better replicating peripheral vision.

Equally important is tracking accuracy. For most vocational training scenarios, systems that offer six degrees of freedom (6DoF) are essential. These allow learners to move forward, backward, up, down, and rotate in all directions within a virtual space, creating a sense of physical presence that enhances both skill acquisition and user confidence.

Comfort and adjustability should not be overlooked. Headsets must be lightweight, well-balanced, and adjustable to accommodate a wide range of users. Features such as Inter-Pupillary Distance (IPD) settings, compatibility with prescription glasses, and proper facial support help ensure a comfortable fit and reduce physical strain during extended use. The effectiveness of any immersive training program can be undermined by poorly fitting or uncomfortable equipment.

Another key component is controller functionality. Advanced VR controllers allow for fine-grained interaction with virtual environments, enabling users to manipulate objects, gesture naturally, and receive haptic feedback. These features are especially valuable when training involves tasks that require manual dexterity or spatial reasoning, such as equipment assembly, surgical procedures, or customer service simulations.

In terms of specific devices, several headsets have emerged as reliable choices for professional training environments. The **Meta Quest 3 and 3s**, a standalone device, is highly portable and cost-effective, offering robust tracking capabilities without the complexity of external hardware. Its ease of use makes it ideal for classroom and field-based applications. The PICO series of devices is also a notable choice for standalone VR. The **HTC Vive Focus 3**, also a standalone unit, is built with enterprise deployment in mind and provides superior processing power and comfort for extended training sessions. For scenarios that demand high-fidelity graphics and precise spatial interaction—such as engineering design or architectural walkthroughs—the **Varjo XR-4 and Primax Crystal** (reaching a resolution of 12K (!)), both PC-tethered systems, offer unmatched visual performance and customizability.

In the context of the choice of platform (PC VR vs standalone) - we refer to an earlier piece of material, describing these solutions.

Co-funded by the European Union

When preparing a training room, additional considerations must be addressed. The physical space should be adequate to define a guardian boundary, ensuring that users remain safely within a designated area while immersed. Network infrastructure must be evaluated, particularly if the training involves multiplayer interactions or synchronized sessions. Finally, charging logistics should be planned in advance, whether through docking stations, extra battery packs, or continuous power connections to support uninterrupted use.

In short, the effectiveness of a VR-based training program depends as much on thoughtful hardware selection and environment preparation as it does on the content itself. The right combination of technology, ergonomics, and deployment strategy creates a reliable foundation for immersive learning.

3.c. Standard Elements of HMD Kits

An HMD kit typically includes the following standard elements:

- **Headset**: The primary display and tracking unit that houses screens, cameras (for inside-out tracking), and sensors.

Figure 6. Oculus MetaQuest 2 headset

Co-funded by the European Union

- **Controllers**: Handheld devices that allow interaction with virtual environments. They often include buttons, triggers, touchpads, and thumbsticks.

Figure 7. Oculus MetaQuest 2 controlllers

- **Cables and power adapters**: Required for setup and continuous use, particularly in tethered systems.

Figure 8. Oculus MetaQuest 2 powercable

Co-funded by the European Union

- **Carrying case or storage box**: For safe transport and organization.

Figure 9. Oculus MetaQuest 2 case

Understanding these components ensures that instructors and learners are prepared for effective use, setup, and troubleshooting.

3.d. Principles of Safe Use of HMD Kits

Virtual Reality introduces a unique set of safety considerations, largely due to the sensory isolation it imposes on the user. Once immersed in a virtual environment, individuals are often unaware of their immediate physical surroundings, which increases the risk of accidents or discomfort if not properly managed. To mitigate these risks, a number of precautions must be integrated into the training setup and user preparation.

First and foremost, a clearly defined play area is essential. Most modern headsets include built-in guardian systems that allow instructors or users to establish virtual boundaries, which prevent collisions with walls, furniture, or other obstacles during use. These boundaries must be set up carefully for each session, particularly in shared or reconfigured spaces. If you are a trainer or teacher and take personal responsibility for the safety of the trainees in your care (which is especially important when teaching young people), it is probably reasonable to set security area boundaries that are slightly smaller than the available playing space - security systems will warn you when you are approaching an area boundary, but keep in mind that in the case of dynamic motion, the user's reaction time to a warning of this type may not be sufficient, and it is worth leaving yourself some safety buffer.

Co-funded by the European Union

Equally important is the physical and cognitive readiness of participants. VR should not be used when individuals are ill, fatigued, under the influence of substances, or experiencing disorientation. These conditions can heighten the risk of simulator sickness or interfere with users' ability to safely engage with the content. Session durations should be monitored and limited, especially for new users, as prolonged use may lead to eye strain, nausea, or dizziness.

First-time users require particular attention. Their reactions to immersive environments can vary significantly, and they may be more prone to disorientation or discomfort. Supervision during initial sessions and the option for frequent breaks can help ease the transition into VR. Users (especially newcomers to VR) should take regular breaks - at more frequent intervals for new users (roughly every half hour).

Because the device is worn on the head, you may experience pain in the muscles or joints of your neck if you use it for a long time. If you start to feel fatigue or pain in any part of your body, or if symptoms such as tingling, numbness, stiffness appear, you should stop using the device for a while.

Hygiene is another critical component, especially in shared environments. Headsets should be disinfected between uses, and the use of disposable face covers is recommended to maintain sanitary conditions. Additionally, systems with tethered headsets must be checked for cable safety—loose cords can easily become tripping hazards or entangle users unaware of their surroundings.

Every VR training session should begin with a brief but comprehensive safety orientation. Users must be informed about how to safely remove the headset in case of distress, how to pause or exit the experience, and how to recalibrate tracking if the system loses spatial awareness. By proactively addressing these concerns, instructors can create a secure and comfortable environment that allows learners to focus entirely on the immersive experience ahead.

3.e. Fitment, Adjustment and Booting of HMDs

Before any meaningful training can begin in a virtual environment, the headset must be properly fitted, adjusted, and powered on—a process that, while seemingly straightforward, plays a critical role in user comfort, safety, and the overall effectiveness of the session.

The fitment of the Head-Mounted Display is the first and most crucial step. A poorly fitted headset can lead to visual distortion, discomfort, or even motion sickness. Each user's head shape, eye spacing, and comfort preferences vary, so adjustments must be made individually. The headset should sit snugly but not tightly on the head, with the display positioned to align naturally with the user's line of sight. Many modern devices include adjustment straps—top, side, or rear-mounted—

Co-funded by the European Union

allowing the headset to be evenly balanced and firmly secured. For users wearing glasses, proper spacing must be maintained to prevent pressure or lens fogging, and compatible headsets often include glasses spacers or dial-based adjustments.

Figure 10. Mounting VR gogles

Equally important is the inter-pupillary distance (IPD), which refers to the space between the lenses in the headset and must match the distance between the user's eyes. Misaligned IPD can result in double vision or blurring, significantly reducing immersion and increasing the chance of eyestrain. Most headsets allow for manual or software-based IPD adjustment, and it's important to take the time to calibrate this before starting.

Co-funded by the European Union

Figure 11. Adjusting space between lenses

Once the headset is comfortably fitted, the booting process can begin. For standalone devices, this typically involves pressing and holding a power button until the device vibrates or displays an LED indicator. Users are then prompted to define or confirm their physical play area using safety system, ensuring they remain within a safe boundary during use. For tethered systems, the startup process includes connecting the headset to a compatible PC, launching the VR platform software, and ensuring that external sensors (if used) are correctly positioned and powered.

Controllers should also be paired and checked before the session begins. These are often automatically detected, but may require charging or firmware updates if not recently used. A brief system calibration—ensuring proper tracking of the headset and controllers in the physical space—finalizes the setup.

Taking the time to complete these steps thoroughly ensures a seamless entry into the virtual environment. When users are comfortable, well-oriented, and free from distractions caused by fit or technical issues, they are more likely to engage fully with the training content, retain information effectively, and enjoy the experience. Proper setup is not merely a technical prerequisite—it is the foundation for successful immersive learning.

Co-funded by the European Union

4. System Setup and User Interface Navigation

4.a. Setup, Security Systems, and Gameplay Environment

The effectiveness of any VR-based training session is closely tied to the physical setup of the environment in which it takes place. A well-organized and secure physical space enhances immersion while minimizing safety risks and technical complications. Since VR users are visually and aurally detached from their surroundings, it becomes the responsibility of facilitators or instructors to ensure that the real-world environment is properly prepared.

The first step is to designate a **safe and unobstructed play area**. For standalone VR headsets, the built-in guardian or boundary system prompts users to define the perimeter within which they can move safely. This digital perimeter is then visualized within the headset if the user approaches the edge, acting as a protective alert. It is important that this boundary be drawn conservatively, taking into account furniture, equipment, walls, and other participants in the room. For room-scale applications, a minimum area of 2 x 2 meters is generally recommended.

Lighting also plays a significant role, particularly for headsets that rely on **inside-out tracking** (where cameras on the headset scan the environment). The training space should be evenly lit—bright enough for cameras to detect spatial reference points, but not so bright that it causes glare or infrared interference. Reflective surfaces such as windows, mirrors, or glass panels can confuse tracking systems and should be covered or avoided when possible.

In more advanced or multiplayer setups, **network connectivity** becomes a factor. Devices should connect via a secure and stable Wi-Fi network, and latency should be minimized to ensure synchronized experiences. For PC-based VR, wired connections and adequate bandwidth are essential, particularly in environments where multiple headsets operate simultaneously.

Once the play area is secured and the headset initialized, the final setup step is to load the training module or VR application. This may involve navigating a launcher interface, logging into a training platform, or connecting to a multiplayer session. It is advisable to conduct a brief trial run with each device prior to formal training sessions to ensure all systems respond correctly.

Co-funded by the European Union

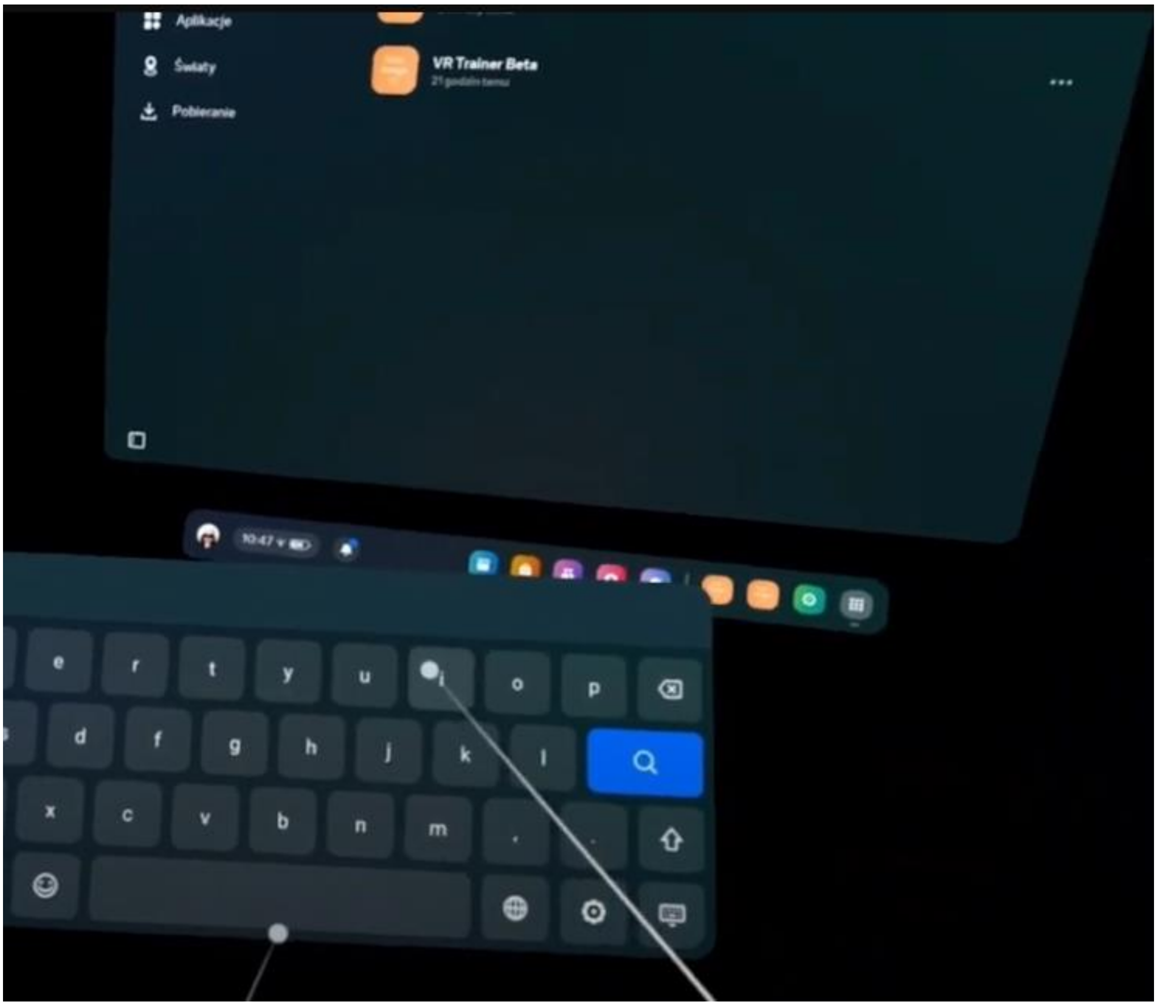

Figure 12. Launching VR app

4. b. Operating Principles and Navigating Interfaces

Modern VR systems are designed to be as intuitive as possible, but familiarity with their core operating principles remains essential—both for instructors and participants. Each headset platform features a home interface, similar to a desktop or mobile OS. This is where users can launch apps, adjust settings, check battery status, and pair controllers. It is also where system notifications or error messages may appear, such as tracking issues, low battery warnings, or network connectivity alerts.

Navigation within these interfaces typically relies on controller input, with one controller often designated for selection and interaction. The controller may include a trigger, grip button, thumbstick, and menu or system buttons. In some systems, hand-tracking replaces controllers entirely, allowing for gesture-based interaction, though this is less common in structured training contexts due to reliability and complexity.

Co-funded by the European Union

The design of VR user interfaces (UIs) follows key principles of visibility, responsiveness, and orientation. Elements like text boxes, icons, and navigation panels are presented within the 3D space—either anchored in front of the user or floating within an adjustable field of view. Interactive elements often highlight or animate when targeted with a pointer or gaze, confirming readiness for input.

Navigation within VR environments is either spatial (physically moving) or virtual (via teleportation or joystick). For training purposes, teleportation remains the preferred method as it minimizes simulator sickness while maintaining mobility. Systems that use 6 Degrees of Freedom allow for natural movement within the boundaries of the physical play space, offering a strong sense of embodiment and control. Bear in mind that this mode of locomotion requires a larger playing space and is generally not suitable for teaching a group and in the context of the classroom

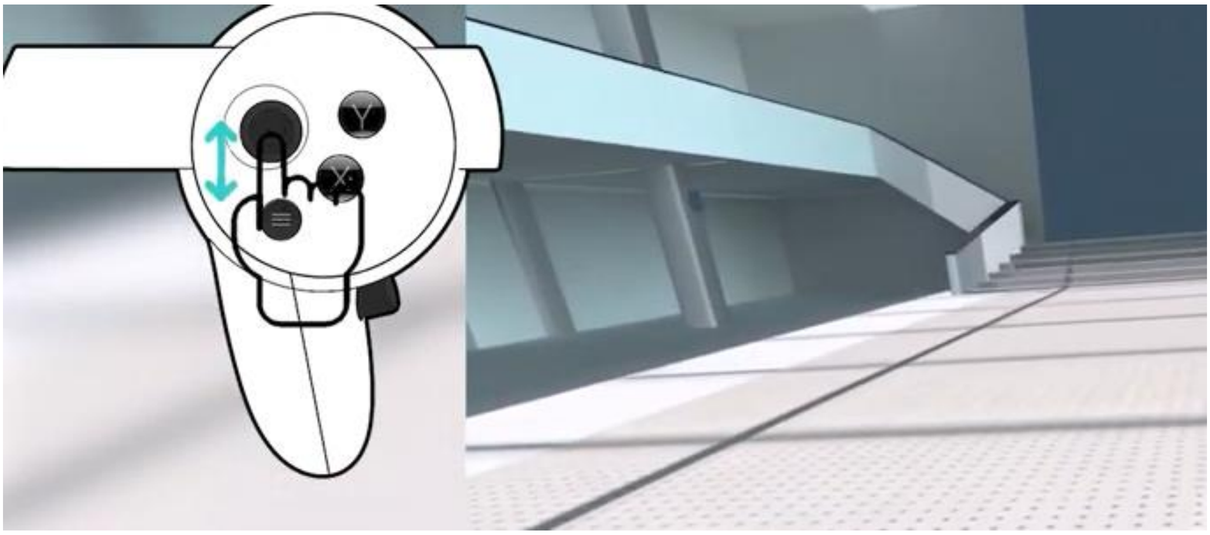

Figure 13. Teleporting or moving with left controller joystick

Importantly, every training session should include a brief orientation period where users are introduced to the interface layout, input methods, and navigation tools. This orientation ensures that users do not waste time struggling with unfamiliar controls, and it empowers them to explore the training content confidently and independently.

Co-funded by the European Union

5. Extended Capabilities and Integration

5. a. User Tracking and Peripherals

Beyond the core headset and controllers, VR systems can be extended with a variety of tracking technologies and peripheral devices that enhance realism, precision, and accessibility in training environments. These extensions serve to adapt the experience to the needs of specific disciplines—ranging from fine-motor control in medical procedures to full-body movement in physical rehabilitation or sports training.

User tracking in most modern headsets is handled through inside-out tracking, where cameras embedded in the headset scan the surrounding space and detect the position of the controllers. While this system works well for general use, certain advanced applications may benefit from external tracking systems, such as the base stations used in PC-tethered systems like the Valve Index or HTC Vive Pro 2. These stations provide centimeter-level accuracy (even less, in some cases), enabling detailed motion analysis or the use of additional body-mounted trackers.

For scenarios requiring hand precision, finger-tracking gloves can replace or supplement standard controllers. These devices capture the position of individual fingers and joints, allowing for more natural interaction—useful in surgical simulations, sign language training, or any environment where hand gesture accuracy is critical.

Haptic feedback devices provide another layer of realism by generating tactile and force sensations when users interact with virtual objects. These can range from simple vibrations in controllers to complex vests, suits, or exoskeletons that simulate resistance, pressure, or impact. Haptics are particularly valuable in training that involves tool handling or physical manipulation.

Additional peripherals can also include:

- Eye-tracking modules, which track gaze direction and pupil dilation for attention monitoring or adaptive feedback.
- Treadmills or movement platforms, which simulate walking or running without requiring large physical spaces.
- Specialized input panels or props, such as steering wheels, flight sticks, or simulated medical instruments.

Integrating these devices requires careful planning. Not all applications support every peripheral, and additional calibration or driver installation may be needed. Most solutions of this type are also only compatible with selected models of HMD kits. Therefore, it is advisable to carry out appropriate

Co-funded by the European Union

research. However, when implemented thoughtfully, these technologies allow for an expanded range of learning scenarios and a more immersive, measurable, and transferable training experience.

5. b. Streaming and Content Sharing

In structured training environments, particularly those involving multiple learners or instructor-led sessions, the ability to stream or mirror VR content from the headset to an external display becomes a powerful instructional tool. It allows observers—trainers, supervisors, or peers—to monitor the VR user's actions in real time and provide immediate feedback or guidance.

Most standalone headsets, such as the Meta Quest series, offer built-in streaming functions. These allow the headset's view to be cast to:

- A local monitor or projector (via Chromecast or compatible smart displays)
- A desktop browser on the same Wi-Fi network
- A recording interface, for post-session review or documentation

For more advanced setups, especially in multi-user or enterprise environments, third-party tools or integrations with learning management systems (LMS) can support live streaming over the internet, multi-user synchronization, or video capture with telemetry overlays. This is particularly useful in scenarios where learner actions need to be assessed, recorded, or reported for certification or evaluation purposes.

Streaming transforms VR from a solitary experience into a shared one, enabling collaborative learning, guided correction, and broader pedagogical control. It empowers trainers to intervene in real time and creates opportunities for peer learning and reflection.

Co-funded by the European Union

6. VR in Practice – Implementation and Sustainability

6. a. Implementing Training Processes Using VR Tools

Successfully integrating Virtual Reality into a vocational training program requires more than hardware setup—it demands thoughtful instructional design, alignment with learning outcomes, and careful orchestration of the training process. VR must be treated not as a standalone novelty, but as a functional and strategic component of a broader educational framework.

The foundation of implementation lies in clearly defined learning objectives. Each VR module should be aligned with measurable outcomes that reflect both theoretical knowledge and practical competencies. For example, a training module for construction joinery may focus on safely handling power tools and executing precision cuts. In a hospitality context, a virtual kitchen might teach learners how to prepare multiple dishes simultaneously while managing time and hygiene.

VR excels in scenario-based learning. Unlike static or lecture-based methods, immersive simulations allow learners to explore real-world challenges in safe, repeatable environments. Mistakes made in VR carry no physical risk but offer strong pedagogical value—encouraging reflection and refinement. Modules can be organized into learning sets that reflect increasing complexity or specificity, serving as the building blocks of vocational qualifications or certification programs.

Integration with assessment mechanisms is essential. Many VR applications track user performance automatically—recording completion times, error rates, movement patterns, or decision-making paths. This data can be analyzed to assess individual progress or group performance trends. Combined with instructor observation or peer feedback, it forms a robust basis for both formative and summative evaluation.

Furthermore, VR can support blended learning models. Virtual modules may precede, follow, or complement in-person instruction, forming part of a flipped classroom or hybrid curriculum. They are particularly effective for preparatory training (e.g., orientation to new tools or procedures) or post-training reinforcement (e.g., simulation of rarely encountered scenarios).

Successful implementation also hinges on facilitation training. Instructors must be comfortable not only using the technology but also guiding learners through it—knowing when to intervene, how to manage simulator sickness, and how to interpret digital performance data.

Co-funded by the European Union

6. b. Multiplayer and Networked Collaboration

Networked collaboration adds a dynamic social dimension to VR training applications. In scenarios such as team-based emergency response, group construction projects, or classroom-based learning environments, real-time interaction between users is essential. To facilitate this, the system must incorporate reliable networking protocols, avatar representation, and session management features.

Multiplayer functionality requires synchronization of user positions, hand movements, voice communication, and interaction states. Technologies such as Photon Unity Networking (PUN) or Unity Netcode for GameObjects are commonly employed to create scalable peer-to-peer or server-authoritative architectures. These tools manage matchmaking, lobby creation, and session persistence.

Each user is typically represented by an avatar, which may include customizable elements such as appearance, name tags, and status indicators. Voice chat is integrated using positional audio, ensuring that voices are spatialized relative to user position in the virtual world. This enhances immersion and simulates real-world group dynamics.

Figure 14. Users as avatars can enter common spaces based on their license and permissions and communicate using Voice chat technology.

Collaboration mechanics can include shared whiteboards, co-manipulable objects, and synchronized scenario progression. Instructors may be given control over pacing, scenario resets, or

Co-funded by the European Union

user inputs. Observers can be granted spectator permissions to review performance without affecting the environment.

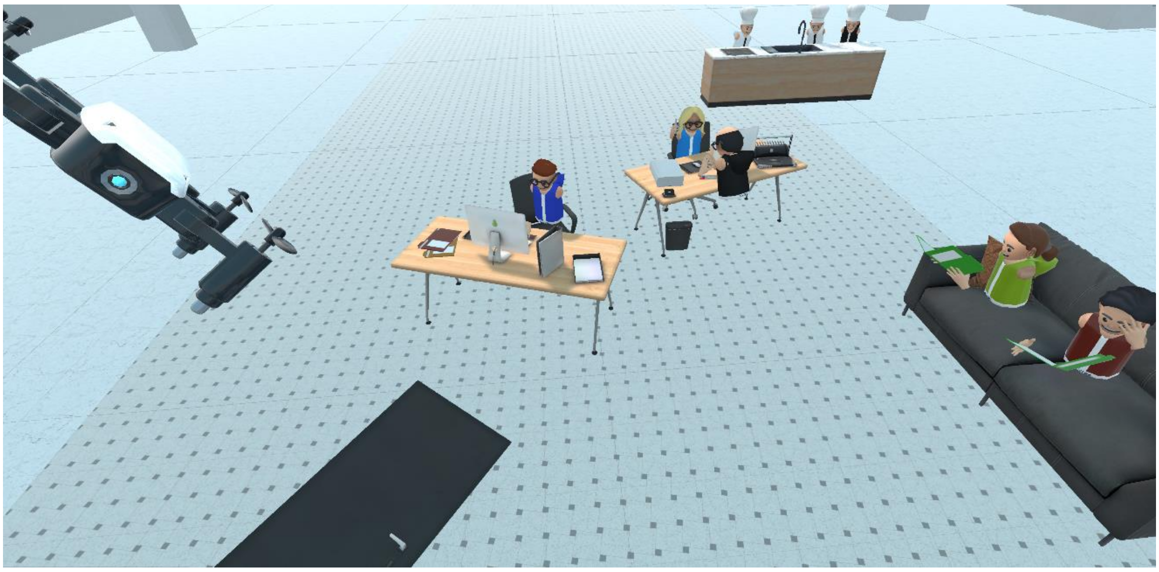

Figure 15. Bird-eye view of the environment coming from the supervisor who can be invisible (ghost mode) for the users

Reliable multiplayer systems must also implement reconnection handling, latency compensation, and data consistency checks to prevent desynchronization. These features ensure that users experience a smooth, collaborative training session regardless of network quality.

6. c. UI interactions and permissions

Within a VR training system, user interactions fall broadly into two categories: object interaction and UI interaction. Object interaction involves manipulating virtual items—picking up tools, opening doors, pressing switches, and assembling components. These interactions emulate real-world physical behavior and are integral to hands-on training scenarios.

In contrast, UI interaction includes engaging with digital menus, informational panels, progress trackers, or virtual keyboards. These elements enable users to configure settings, receive instructions, and track their learning progress. They are essential for navigating between training modules or accessing learning resources.

Co-funded by the European Union

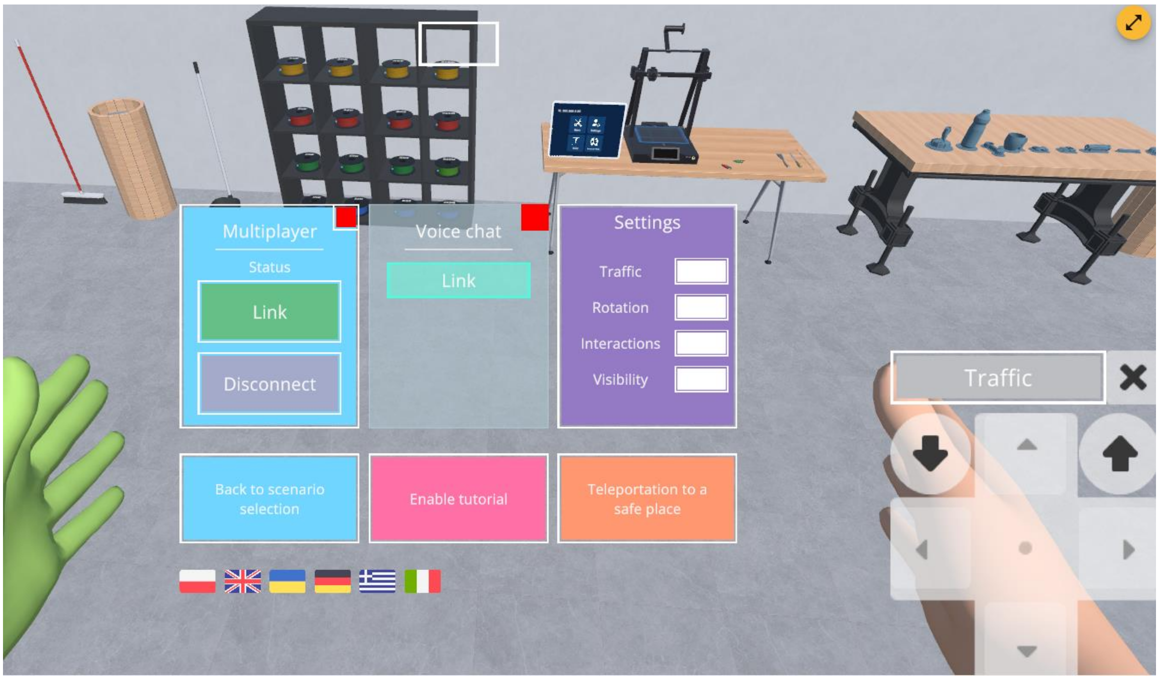

Figure 16. A menu allowing users to customize or switch on/off different functionalities such as Multiplayer mode.

The application should differentiate between these two modes of interaction to prevent conflicts and streamline user input. For instance, a user holding a virtual object should not inadvertently trigger a UI action, and vice versa. Clear interaction hierarchies and visual cues (such as raycasts or proximity outlines) help the user understand the current mode of interaction.

Figure 17. Headset view demonstrating raycast to manipulate the virtual environment with the controller button

Co-funded by the European Union

Permissions can be layered to reflect different user roles. A learner may have full control over object interaction, while an instructor or observer may only access the user interface to view statistics or monitor progress. Some applications include a supervisor role that allows the user to control the pacing of a group session, reset scenarios, or provide assistance without directly manipulating training content.

Figure 18. Supervisors can monitor and evaluate progress both from inside the VR application (headset on) or followed via flat application on a desktop/mobile device screen.

In virtual reality training applications, the user interface (UI) plays a critical role in shaping how learners interact with content and navigate tasks. Unlike conventional 2D screen-based systems, UI elements in VR exist within the 3D space of the simulation itself. Interactions are performed not through mouse clicks or keyboard inputs, but by natural gestures, gaze, or physical hand movements. Each type serves a specific instructional purpose—ranging from delivering contextual information to enabling physical control over virtual environments. Their design follows ergonomic principles that promote clarity, immersion, and usability within spatial experiences.

Implementing a diverse set of UI elements allows the training system to accommodate different interaction models and learning outcomes. Whether through passive reading or active manipulation, each component contributes to building an engaging, informative, and measurable training experience.

Co-funded by the European Union

The VR interface could comprise the following types of components:

Text panels - static elements placed within the virtual space. They provide context-relevant information, such as step-by-step instructions or system messages. These panels are passive—users read the content without needing to interact physically.

Examples of use: Task instructions during simulation steps, Descriptions of tools or objects, Notifications like “Stage Complete” or “Proceed to Next Area”.

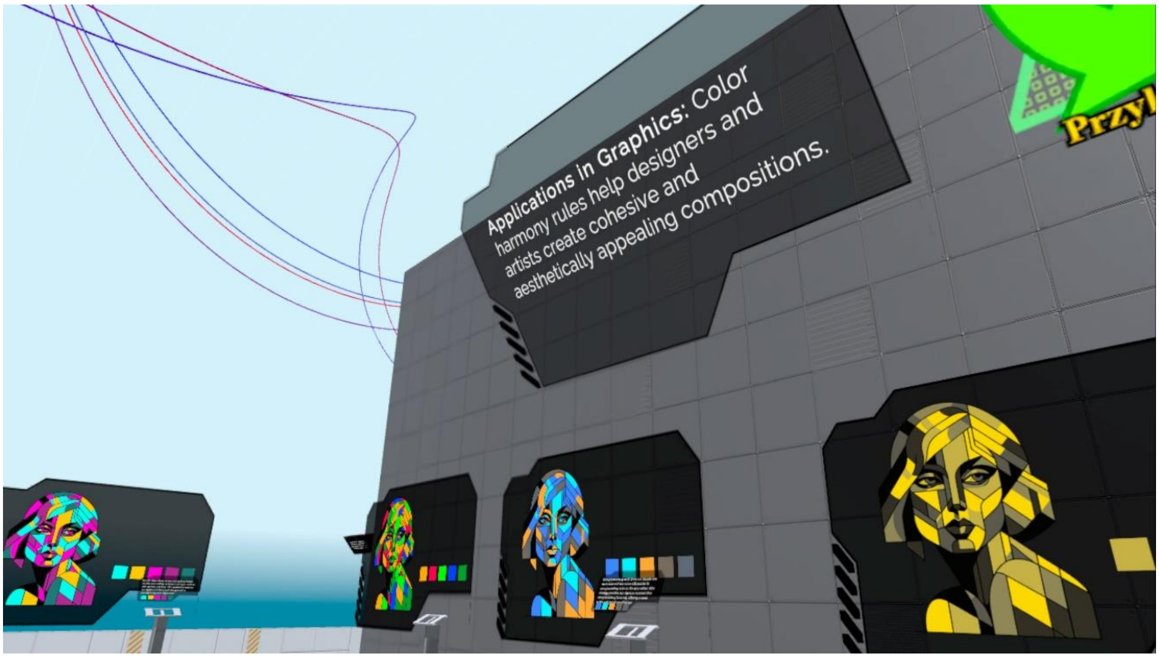

Figure 19. Text panels within Virtual Reality holding relevant information

Gaze-Activated Text Panels - These panels appear only when the user looks directly at them or highlights them with a laser pointer. Once triggered, the content remains visible for a specified duration before disappearing. This enables the delivery of dynamic, non-intrusive contextual hints while keeping the environment visually clean.

Examples of use: On-demand explanations tied to specific objects, Labels that activate when noticed, Instructional tips that fade after being read.

Figure 20. Gaze activated panels which dynamically display information

Graphic Panels - Graphic panels display visual content—either as static images or dynamic sequences. They help illustrate complex tasks, present visual comparisons, or reinforce instructions through reference images or diagrams.

Figure 21. Graphic panels containing text and images

Co-funded by the European Union

Physical Manipulators - These are interactive 3D objects that can be grabbed, rotated, or moved using natural gestures. Physical manipulators simulate real-world tools and interfaces, giving users a tactile sense of interaction within the simulation.

Examples of use: Turning valves, pulling levers, or sliding controls, Adjusting machine settings like temperature or speed, Simulating hands-on equipment operation.

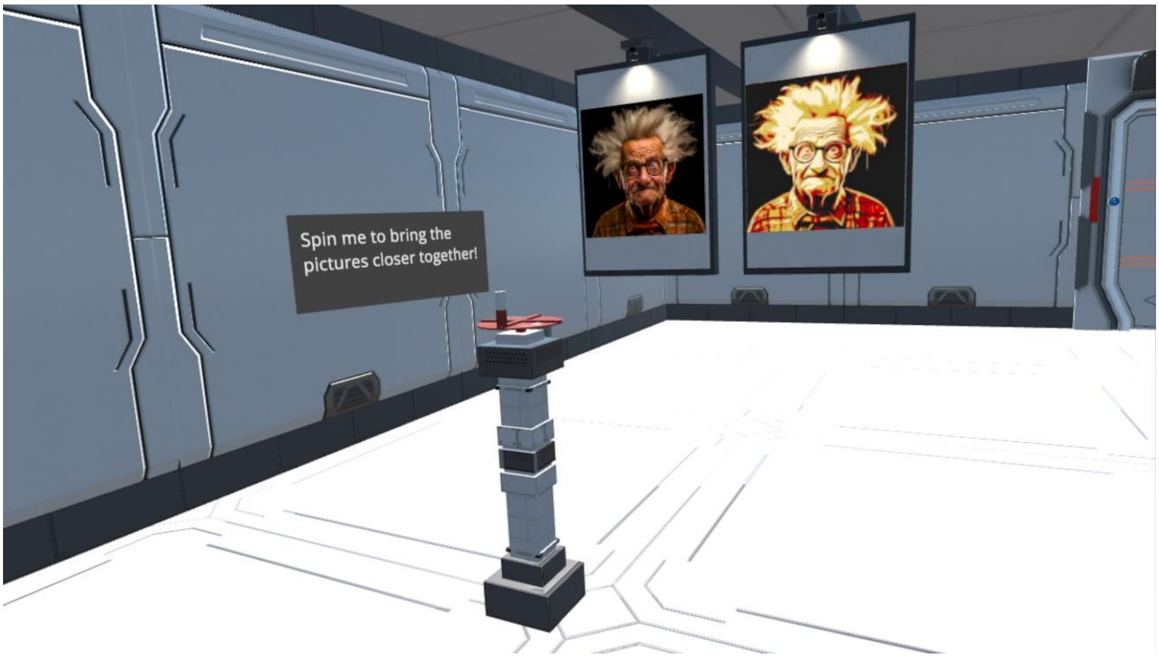

Figure 22. A spinner which can bring images closer or push them away

Physical Buttons- Physical buttons are objects that respond to pressing or touching. They are commonly used to trigger system actions—such as launching a new module, confirming a decision, or switching between training modes. They are often part of control panels within the virtual space.

Examples of use: Starting or stopping simulations, confirming user input or task completion, activating learning/test mode toggles

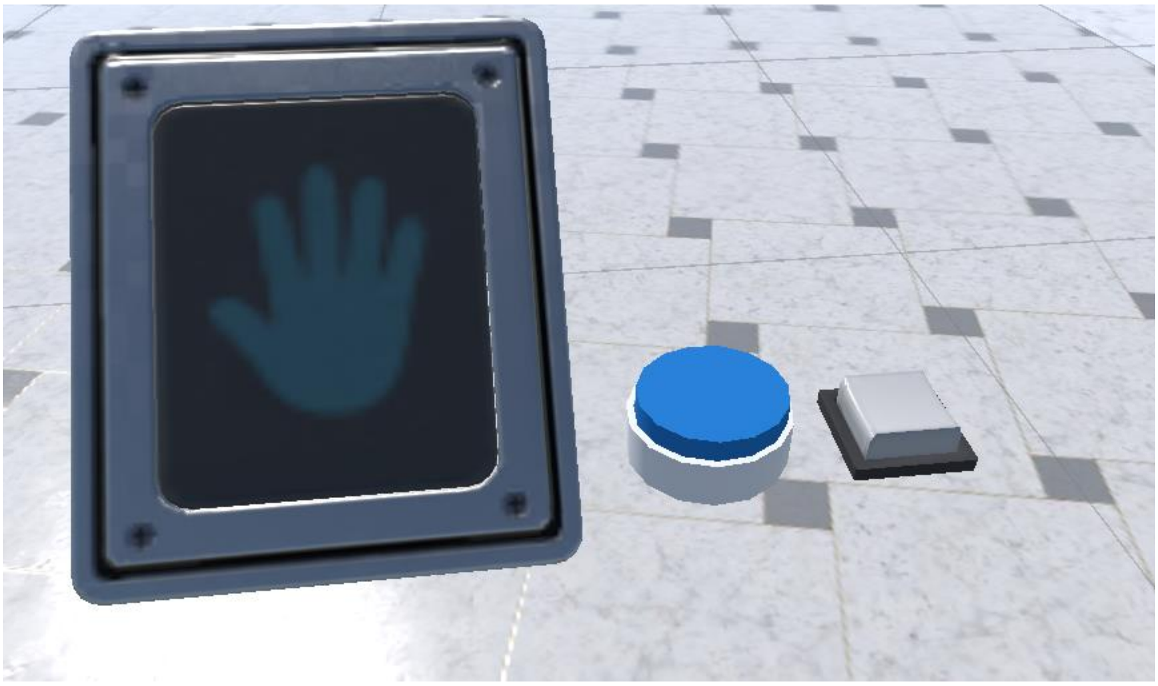

Figure 23. Buttons activating different elements of VR scenarios

6. d. Maintenance and Long-Term Equipment Care

As with any professional training resource, VR equipment must be maintained systematically to ensure its longevity, reliability, and safety. Regular upkeep also supports user satisfaction and minimizes session downtime due to technical failures or health concerns.

The first pillar of maintenance is hygiene. HMDs and controllers are in direct contact with the face and hands, which makes them vulnerable to contamination—particularly in shared-use settings. After each session:

- Wipe all surfaces with approved disinfectants
- Replace or sanitize face cushions and disposable face covers
- Avoid moisture accumulation, especially around lenses and foam

When cleaning the headset, be careful not to wipe the lenses with cleaning agents, as this can damage the device. Equally sensitive are the optics on the outside of the headset housing (pass cameras and sensors located on the housing of headsets using selftracking mechanisms).

Many training providers now opt for silicone face covers, which are easier to disinfect than fabric or foam. UV sanitation boxes are also used in high-throughput environments.

Co-funded by the European Union

Battery management is another critical aspect. For standalone headsets:

- Charge devices fully after use
- Avoid deep discharging, which can shorten battery life
- Use USB-C hubs or charging stations to maintain readiness

Where continuous use is expected, institutions may invest in hot-swappable battery systems, enabling quick changes without powering down the device.

When transporting equipment—especially between training sites—headsets, controllers, and accessories should be stored in padded, shock-resistant cases. Movement can disrupt internal sensors or damage lenses if not properly protected. Always remove loose batteries or ensure devices are powered off during transit.

Storage conditions also matter. HMDs should be kept in cool, dry environments, away from direct sunlight. Prolonged exposure to sunlight—especially through lenses—can damage the screen permanently.

Finally, VR systems require regular updates and diagnostics. Firmware, tracking calibration, and application software should be reviewed monthly. Assigning a dedicated system administrator or technician can ensure that all devices remain secure, updated, and aligned with training requirements.

By incorporating these long-term practices into the training ecosystem, organizations ensure that VR remains a sustainable and cost-effective tool—not only for current cohorts but for years of learners to come.

Co-funded by the European Union

7. Summary

Virtual Reality is rapidly transforming the landscape of vocational education and professional training, offering immersive, interactive environments that enhance skill acquisition, safety, and learner engagement. This workshop provides a comprehensive introduction to VR and its related technologies—Augmented Reality (AR), Mixed Reality (MR), and the broader category of Extended Reality (XR)—guiding participants through both the theoretical foundations and practical implementations of immersive learning.

The training begins with a historical overview of VR's evolution, from early experimental systems to today's advanced, commercially available platforms. It clarifies the distinctions between VR, AR, MR, and XR, and establishes a clear understanding of what constitutes a true virtual reality environment. Participants gain insight into the core components of VR technology, including head-mounted displays (HMDs), motion tracking, spatial audio, and user interface elements.

Attention is then given to the range of VR platforms—PC-based, standalone, and legacy mobile systems—highlighting how hardware should be selected based on learning objectives, user profiles, and environmental constraints. Proper fitting, adjustment, and booting procedures are emphasized to ensure user comfort and readiness. Best practices for physical setup, safety, hygiene, and spatial awareness are presented to support a secure and efficient training environment.

The workshop also explores extended capabilities of VR systems, such as the integration of hand-tracking gloves, haptic devices, eye-tracking modules, and content streaming tools. These enhancements expand the range of training scenarios and allow for real-time feedback, collaborative learning, and comprehensive performance evaluation. The final component focuses on implementation—designing training modules around specific learning outcomes, aligning immersive activities with qualification frameworks, and maintaining equipment for long-term use.

By the end of the program, participants will have the knowledge and confidence to incorporate VR into structured training environments, ensuring that immersive tools are used not only effectively but sustainably. This workshop empowers trainers, educators, and technical staff to lead the next generation of digital learning with purpose, precision, and innovation.

Co-funded by the European Union

8. List of Illustrations

Co-funded by the European Union

9. References

META, 2024. Oculus Quest 2 User Guide. Available from: https://www.meta.com [Accessed 4 May 2025].

UNITY TECHNOLOGIES, 2025. Unity XR Development Manual. Available from: https://docs.unity3d.com [Accessed 4 Jun. 2025].

VPL RESEARCH, 1990. Historical Innovations in VR Technology. Journal of Virtual Systems, 2(3), pp. 45–58.

LEGE, R. and BONNER, E., 2020. Virtual reality in education: The promise, progress, and challenge. The JALT CALL Journal, 16(3), pp.167–180. Available from: https://doi.org/10.29140/jaltcall.v16n3.388 [Accessed 5 Jun. 2025].

KAVANAGH, S., LUXTON-REILLY, A., WUENSCHE, B. and PLIMMER, B., 2017. A systematic review of virtual reality in education. Themes in Science and Technology Education, 10(2), pp.85–119.

DUBOVIK, O., 2024. Immersive VR learning effectiveness in technical education: A meta-analytic study. VR Learning Effectiveness Journal, 21(1), pp.35–52.

Co-funded by the European Union