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Creative Teaching through Virtual Reality

Guide to integrating virtual or augmented reality in adult education and training

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1. Introduction

In the ever-changing landscape of education, technology plays a central role, transforming traditional teaching methods and learning opportunities. Among the technologies being deployed are virtual reality (VR) and augmented reality (AR), which enable the creation of new learning situations.

Adults come to training with diverse experiences, motivations and expectations. Between work, family and other activities, they want training to be flexible, relevant and stimulating. Virtual and augmented reality technologies offer immersive environments, enabling people to interact with content in ways they never imagined before. Whether simulating real-world scenarios, visualizing complex data or facilitating collaborative learning, they are a source of enrichment. For adult education in many ways.

However, their integration into adult education is not simply a matter of creating visually stunning digital worlds. It requires a strategic approach, ensuring that the technology serves pedagogical objectives, meets learners' needs and respects ethical considerations. Trainers wishing to exploit its potential must do so methodically, after training themselves.

This guide serves as a roadmap for professionals at the intersection of technology and training. From understanding the diversity of adult learners to the technical complexities of platforms, from guaranteeing inclusivity and accessibility to updating and evaluating content, every aspect is explored, ensuring a comprehensive integration of these tools.

What's more, like any technological integration, the implementation of VR/AR in education comes with its own set of challenges: technical ones, initial resistance from stakeholders, data confidentiality or the risk of digital fatigue among learners. This guide proposes concrete solutions to overcome these challenges and ensure that integration proceeds smoothly, with a positive impact.

While technology serves as a support, content, pedagogy and the learner's experience remain at the heart of our work. Our ultimate goal as trainers remains the same: to facilitate meaningful, engaging and effective learning experiences for adults.

2. The evolution of adult training with a virtual or augmented reality

Historically, adult education has been distinguished from other forms of education by its focus on meeting the immediate and concrete needs of adults, whether for professional advancement, personal development or adaptation to changes in society.

The integration of virtual or augmented reality supports these principles and makes the learning experience more immersive and personalized. It can transport learners into virtual environments where they will exercise their skills in a controlled but realistic setting. Whether it's a virtual workshop, a meeting simulation or a 3D replica of an archaeological site, it facilitates contextual and experiential learning.

Augmented reality, on the other hand, superimposes digital information on the real world, enhancing the learner's perception and interaction with his or her environment. This is particularly useful for on-the-job training, where real-life situations can be enriched with digital information, or for tasks requiring immediate correction.

Another advantage is the potential for personalization: everyone's experience can be tailored to their needs, learning pace and preferences.

Finally, the social aspects should not be overlooked: learners from all over the world can interact in virtual classrooms with a sense of community. This abolishes geographical distances and integrates diverse perspectives into the learning experience.

Virtual and augmented reality technologies in adult education enable enriched, interactive and personalized learning. As these technologies mature and become more accessible, the field of applications for education and training expands.

2.1. Historical development

The field of adult education and training has always been explored by technologies, seeking new ways to make it more attractive, more adapted or more accessible. After relying on face-to-face interaction, first with textual content, then audiovisual, then remote with the Internet, the emphasis is now on pedagogy that is rich in content, but also in context.

The end of the 20th century saw the experimental beginnings of virtual and augmented reality. The Sensorama, a kind of arcade console with sensory sensors developed in the late 1960s by virtual reality pioneer Morton Heilig, was not designed with education in mind, but had an impact in this field despite significant obstacles: immature technology, prohibitive costs and lack of content. At the same time, augmented reality consolidated its position in the early 1990s, with applications in the military and aeronautical sectors, before educators became interested in its potential.

The early 21st^ème^ century has seen a flourishing period of adoption in training, with technology slowly advancing and becoming more democratic. Numerous pilot programs were launched, aimed at testing its viability and usefulness. Learners were able to virtually traverse historical epochs, cosmic expanses and the nooks and crannies of human anatomy, while remaining in a room. The simulations enabled surgical and mechanical professionals to refine complex gestures in a risk-free environment, before applying them in high-stakes real-life scenarios.

From the 2010s onwards, thanks to consumer virtual reality headsets such as Oculus Rift or HTC Vive and the possibility of using augmented reality on smartphones, these technologies became more widespread, but still less so than their potential would suggest.

The challenges posed by the COVID-19 pandemic in the 2020s have accelerated the adoption of various technologies by training organizations. Content was transposed online in response to the limits imposed on physical presence, for educational continuity. Simulated laboratories were used to conduct experiments in scientific disciplines.

While virtual and augmented reality hold great promise, they are still rarely used in adult education, and are confined to certain professional or in-company training courses.

2.2. Learning by doing experience

Virtual reality introduces an experiential dimension, combining "doing" and "learning". Learners no longer simply witness or interact with historical re-enactments or scientific simulations, they become part of them, dynamically engaged in their learning experiences.

Simulations transform risks into opportunities for exploration and experimentation. Understanding and skill development through trial and error become possible. Learners no longer fear the consequences of their actions. They are free to explore and experiment in a journey where theoretical knowledge and practical application converge.

The immediacy of feedback guides every step, decision and action, and can shape the course in a dialogue between the learner, the experience and the virtual environment. This dialogue, whether it's correcting a mispronounced word or adjusting a sales negotiation strategy, becomes an iterative cycle in which actions and corrections are integrated.

The learner is not just an actor, but a decision-maker, a problem-solver and a critical thinker.

Learning becomes richer by mobilizing not only the mind, but also the visual, auditory and tactile senses.

The debriefing phase, during which experiences are analyzed and understood, alone or in groups, helps consolidate learning.

2.3. Autonomous exploration

Virtual and augmented reality technologies support learners' autonomy in managing their learning path. The immersive experience is lived at one's own pace and according to one's own curiosity, in a technologically enriched space offering choices for exploration, and dynamically supporting them. Learners can linger, accelerate or modify their journey.

Not being afraid to make mistakes encourages freedom of experimentation and a depth of exploration.

2.4. Flexibility

The multi-dimensional nature of adult learners' lives, with their different roles and responsibilities, calls for adaptable content. Geographical independence, in particular, appears to be an essential element in promoting inclusion and accessibility, with the possibility of learning from home or the workplace at any time.

The content can be approached in a modular way through a number of different entry points.

Different modes of interaction are possible: whispering commands in the isolated comfort of a private room, or gesturing in a crowded subway.

2.5. Collaboration

Learners of different ages, geographical locations and professional backgrounds can come together in a virtual space, bringing with them a diversity of knowledge, experience and cultural perspectives.

Professionals can immerse themselves in recreated work situations to explore different solutions and strategies with their peers, without fear of real-world repercussions. This strengthens problem-solving and decision-making skills. What's more, solving a problem with a group of people helps them to understand different communication norms and cultural attitudes in real-life situations.

Being in training with others can create a certain emulation. Sharing virtual experiences encourages the exchange of ideas and constructive feedback.

Mentors and experts, too, become more accessible in an informal virtual setting, conducive to curiosity, research and communication.

2.6. Active participation

Learning is not limited to textual or visual interactions. It is possible to manipulate variables and immediately observe the consequences: understanding is built through a continuous, iterative process of action, reflection and refinement.

Reconstructing environments removes distracting elements to focus learners' attention, helping them to grasp complex subjects.

Virtual experiences can arouse emotions that facilitate memory processes.

In addition to counting points or reaching a certain level, gamification techniques can be implemented with activities of increasing difficulty.

Finally, allowing learners to direct their own learning path fosters a sense of ownership, boosts motivation and reinforces their feeling that the training is relevant.

2.7. Individualization

Courses can be customized to offer a tailor-made experience that respects the learner's pace, curiosity and objectives.

Whether aimed at professional development or personal enrichment by focusing more on the acquisition of skills or the discovery of new knowledge, the course can take into account the pace at which knowledge is assimilated or the preferred media.

Last but not least, linguistic and cultural options ensure that the product can be used by everyone.

2.8. Real-world applications

Theoretical knowledge can be experienced and applied in real-life scenarios. Learners become familiar with the functionalities of specialized machines and tools without physical and logistical constraints. Particularly in fields where precision and safety are paramount, such as aviation, medicine or heavy engineering, skills can be honed and safety protocols mastered without the risks and expense that would be necessary in the real world.

Communicating, negotiating and resolving conflicts, helps develop soft skills with applications in healthcare, customer service or consulting.

3. Using virtual or augmented reality in adult training

Virtual or augmented reality offers many opportunities for the education and training of adults with diverse, mature and complex profiles. If technology is to amplify, enrich and deepen learning experiences, it is also a pedagogical challenge to achieve learning objectives and meet the diverse needs of adults.

3.1. Define clear objectives

Integrating virtual or augmented reality requires a symbiotic relationship between technology and pedagogy: immersion, simulations and interactions must be aimed at learning objectives.

Can a virtual visit to an ancient civilization bring the pages of a history book to life? Can augmented reality superimposition and conversion of a flat geometric shape in a textbook into a 3D model enhance spatial understanding?

Technology should not create an isolated experience, but be integrated into a broader educational narrative. What will immersion in the depths of the ocean teach us? What will a virtual walk through a vanished city provide?

3.2. Know your audience

Integrating virtual or augmented reality means understanding learners with their varied skills and backgrounds. Positioning them in practical sessions or by means of a questionnaire enables us to gather information on their technical skills.

In addition, it is essential to analyze potential obstacles, whether of a technical nature, linked to physical handicaps, or to the time constraints of professional or family commitments. Wherever possible, learners will be able to access immersions asynchronously.

Feedback sheds light on the effectiveness and impact of technologies, offering insight into what works and what needs to be improved.

3.3. Choosing the right technology

The choice of appropriate technology, both on the developer's side and for the device that will provide the learner with an immersive experience, depends on budget and development skills, for which scalable modular solutions are preferred.

On the user side, the main visual interfaces are as follows.

- Spherical or cubic immersive rooms (CAVE, Icube, SAS Cube) with synchronized stereoscopic rear projection or direct projection screens. The user is immersed in a room where images are projected onto the walls, floor and ceiling. A position capture system calculates the perspective in real time to respect the user's point of view.

- Virtual reality headsets encompass the user's entire field of vision, broadcasting an image for each eye. The brain combines these two images to transform them into a 3D vision. In addition to stimulating the visual system, they localize the user's head in terms of orientation and translation. This has become the most common interface for virtual reality training. There are two types of helmet:
    - Smartphone-based headsets These are generally low-cost (low price, lower quality), and their performance depends on the smartphone and the application used. This category comprises two types of headset. On the one hand, untethered headsets: a frame equipped with a very rudimentary optical system consisting of a lens for each eye, into which a smartphone is inserted. On the other hand, there are headsets with a headband where the user can adjust several parameters (e.g., intra-ocular distance or sharpness...). With this type of headset, the user can use a joystick or other connected device to move around the environment, and possibly interact.
    - Virtual reality headsets that no longer need to be connected to a computer. With good value for money, the Meta Quest range occupies just over 50% of the market. Version 3, combined with haptic feedback controllers, offers a resolution of 1064 x 2208 pixels per eye, a 110° field of view and support for mixed reality. Despite the quality of the experience they offer, these headsets remain a niche market, with sales declining sharply in 2022 compared with 2021 (-12% in number of headsets sold), then in 2023 compared with 2022 (-40% in sales in the USA)[1] .

To interact in 3D with the virtual environment, the user can use motor interfaces such as localization sensors, specific body localization interfaces and manual motor interfaces. Effort-feedback interfaces are sensory-motor interfaces that enable the user to interact with the virtual environment while perceiving it.

Virtual reality headsets are sold with two controllers, one for each hand, which are more or less ergonomic and offer different interaction possibilities.

The width of the field of view, the sharpness of the image and the high resolution are important elements in creating an impression of reality that requires high computing power.

Augmented reality, which displays 3D content superimposed on a real environment, will be used with a computer, tablet or smartphone. Here too, users will need a minimum of digital skills to enjoy the benefits. The fact that a tablet or smartphone is often in the hand makes the user experience less comfortable.

If you use the services of an external developer, you need to guarantee the continuity of your investment, by ensuring that the solution is scalable and benefits from regular updates, as well as support to guard against premature obsolescence (see Appendix).

[1] https://fr.statista.com/themes/3357/la-realite-virtuelle/#topicOverview

Tools for developers[2]

1. Unity [https://unity.com]

Unity is a multiplatform game engine (smartphone, computer, video game consoles and Web) developed by Unity Technologies. It has the distinctive feature of offering a free "Personal" license, with some advanced technology limitations at the editor level, but no limitations at the engine level. Compared with its main competitor, Unreal Engine, Unity is considered to have a more user-friendly interface and is more suitable for independent creations.

2. Unreal Engine [www.unrealengine.com]

Unreal Engine is a proprietary video game engine developed by Epic Games. Its main competitors are Unity and Crytek's CryEngine. It can be downloaded and used free of charge for non-commercial use.

3. AR.js [https://ar-js-org.github.io/studio]

AR.js is an open-source solution that lets you create augmented reality in 60 fps from a browser, without the need for a native application. AR.js can be used to create websites integrating the following types of augmented reality:

- Image tracking - Identify 2D images and display the corresponding augmented reality content.
- Location-based augmented reality - Display augmented reality content based on location.
- Marker tracking - Using markers such as QR codes to display related augmented reality content.

4. Sketchfab [sketchfab.com]

Sketchfab is primarily a 3D model hosting and playback site, visible in Sketchfab or on external sites. It includes a model gallery. Sketchfab's 3D player uses the WebGL JavaScript API, as well as the open-source OSG.JS library. This enables 3D models to be displayed on web pages without third-party plug-ins if the browser supports WebGL.

5. Blender [blender.org]

Blender is a free software package for 3D modeling, computer animation and rendering, created in 1994 by the Blender Foundation. Increasingly used by companies in the 3D animation sector, it offers advanced functions for modeling (including 3D sculpting, UV texturing and unfolding, etc.), 3D animation (rigging, blend shapes) and rendering. It also handles non-linear video editing, compositing, nodal material creation, and various physical simulations such as particles, rigid bodies, flexible bodies and fluids.

6. ARKit [https://developer.apple.com/augmented-reality/arkit/]

It's a development platform that enables app developers to quickly and easily integrate AR experiences into their apps and games. It uses the camera, processors and motion sensors of an iOS device to create immersive interactions. ARKit uses visual-inertial odometry technology to analyze the layout of a room and detect horizontal planes around the device.

7. ARCore [https://developers.google.com/ar]

[2] This section and the following one, "Tools for teachers and learners", have been written with the help of Wikipedia, based on the various software entries.

ARCore is the software development kit developed by Google to create augmented reality applications that can be read on any Android device. Like ARKit, motion tracking enables the phone to understand and track its position relative to the world, and it detects the size and location of flat horizontal surfaces like the floor or a table.

As new resources are constantly appearing, this list is constantly evolving and it is essential to keep a watchful eye on.

3.4. Integrating virtual or augmented reality into the program

The integration of technology must enhance and enliven the training program. The aim is not to replace, but to enhance, making sure that technology is not a gadget, but a substantial and rewarding component. It must act as a catalyst for learning, without creating new obstacles.

For example, a virtual visit to the Uffizi Gallery in Florence in a course on Renaissance art doesn't just allow you to admire the works of art, but to immerse yourself in a culturally rich and historically significant environment that enriches your understanding of the Renaissance through text.

Virtual or augmented reality will be used at times when it can enhance understanding and retention, for example an augmented reality overlay for an anatomy lesson.

Each session can be followed by reinforcement of the knowledge acquired through traditional methods, discussions or reflective writing assignments, as well as by an assessment to provide information on understanding, assimilation of knowledge and areas for reinforcement.

Examples of virtual reality integration:

- Present a work of art or a historical site
- Reproduce a risky situation or environment (e.g. handling dangerous products, working at heights)
- Train to master a gesture or technical procedure (e.g. tree pruning)
- Inspect a machine with a detailed view and zoom in on specific parts
- Offer realistic immersion in a particular environment (e.g. a building construction site).

Examples of augmented reality integration:

- Project virtualized objects into a real environment to better understand their representation (e.g. visualize a virtualized piping line on a room wall).
- Know the nomenclature of the parts that make up an object (e.g. the names of the parts making up a piping line, etc.).
- Train representation in space (e.g. make the connection between plans and represented objects around which the learner can move)
- Inspect a machine or appliance, thanks to a detailed view and zoom on specific parts

3.5. Prepaired trainers

It's vital to focus on training educators to design innovative teaching strategies and to use simple software or applications to enrich their courses, or simply to use turnkey resources with an understanding of the technique, installation and troubleshooting procedures.

Experimentation with existing resources and exchanges with more experienced trainers will give them confidence and ideas for development.

Practical workshops will familiarize them with tools that will enable them to start integrating augmented reality, which is more accessible to non-specialists.

Developers employed by the organization will be able to take part in basic training to master a dedicated tool like Unity, and then take part in forums.

Finally, it is essential to encourage experimentation by encouraging trainers to incorporate innovative elements into their courses.

Various platforms offer free or paid training courses tailored to developers or trainers. Here are just a few examples:

1. On Fun Mooc, the University of Lyon offers the course *Virtual Reality and Innovative Teaching Practices*, lasting 4 hours (1 hour a week).

2. Coursera [www.coursera.org/

- The "Introduction to Virtual Reality" and "3D Models for Virtual Reality" courses, run by the University of London, cover the fundamentals.

- Yonsei University's *AR & Video Streaming Services Emerging Technologies* course focuses on education.

4. LinkedIn Learning [www.linkedin.com/learning] hosts courses that cover different facets of VR and AR, from the basics to more advanced topics, and deals with specific tools such as Unity or ARKit.

5. Udacity [www.udacity.com] - in English offers a free 3-hour "Introduction to Virtual Reality" course, as well as numerous modules for developers.

6. Class Central [www.classcentral.com] - includes many MOOCs that can be searched by keyword.

It's best to start with general courses that focus on pedagogical applications, before delving into the more technical content creation.

3.6. Encouraging collaborative learning

Collaborative learning can be integrated with role-playing.

Small-group discussions after the simulations help to deepen understanding, bring out new ideas and consolidate acquired knowledge.

Virtual reality fosters interdisciplinary collaboration by breaking down the barriers between disciplines, with a more global approach to situations.

Collaborative learning can be geographically unlimited, with dispersed learners exploring and creating together, solving problems, sharing knowledge and negotiating different perspectives to converge on a solution.

3.7. Focus on interactivity

Passive experiences, such as watching immersive 3D videos or overlaying information in augmented reality, do not allow us to manipulate the environment, make decisions or observe the consequences of actions.

If you have the financial capacity or the necessary technical skills, you'll want to introduce interactions into your virtual reality projects. They generate a deep, experiential understanding of concepts and phenomena.

Interaction-based exploration corresponds to constructivist theories, where knowledge is not simply acquired, but progressively constructed through interaction, exploration and reflection. However, care must be taken to ensure that the sensory and cognitive load of experiences is balanced with the cognitive capacities of learners. Interaction and navigation must be intuitive, and[3] cognitive engagement must be progressive, so that learners are neither overwhelmed by complexity nor disappointed by simplicity.

3.8. Providing advice and support

The creation of guides or FAQs for common problems enables learners and educators to resolve technical difficulties. For their part, educators can call on a technical support team to help them use the integration software.

3.9. Guaranteeing accessibility

This involves diversifying content, providing human assistance and offering alternatives, including non-technical ones, for acquiring the targeted knowledge and skills. The most classic palliatives are the implementation of subtitle options for people with hearing impairments, or audio descriptions for visually impaired users. Attention to navigation ergonomics will benefit everyone.

Alternative control options such as voice commands, eye tracking or other assistive technologies are needed to enable physically disabled learners to navigate.

Learners who are prone to motion sickness or have health problems can take breaks or remain seated.

The multilingualism of the modules will enable them to be distributed more widely.

Developers should not hesitate to train themselves on these issues, or to call on accessibility experts or organizations specializing in inclusive education.

With the use of virtual reality comes the responsibility to ensure that it is accessible, inclusive and empowering for all.

3.10. Evaluate

The continuous evaluation process covers both technical aspects and pedagogical effectiveness. Feedback from trainers and learners is obtained by a variety of means,

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[3] In the field of web applications, engagement has been defined by Attfield et al. (2011) as an emotional, cognitive and behavioral connection between a user and a resource.

including surveys, focus groups and individual sessions. This feedback also sheds light on learner participation and motivation, understanding and areas for improvement.

3.11. Stay informed

The rapid evolution of virtual and augmented reality technologies calls for constant technological monitoring and self-training, in addition to formal training courses. Relationships can be forged with software industry representatives and developers. These will enable us to project ourselves into the future, with educators offering insights into practical applications and learners' needs, and industry experts sharing a vision of development possibilities.

Attending conferences and trade fairs is another way of keeping abreast of technological advances and applications in education, as well as what might be next.

By collaborating with research organizations, educators can not only discover new applications, but also help shape the evolution of virtual reality in educational contexts. This partnership combines practical application with theoretical exploration, each informing and enriching the other.

Online communities provide access to knowledge, experience and support.

3.12. Safety considerations

Immersive technologies run the risk of disturbing people who are physically, psychologically or emotionally fragile.

The disconnect between virtual movement and physical stasis can be nauseating. Sessions will be short or include breaks. An alternative will be offered to subjects suffering from cognitive or psychological disorders.

In the debriefing phase, learners will be able to express their experiences and emotions, and reflect on the place of their virtual experience in a wider learning journey.

3.13. Relationship with traditional learning

In-class feedback helps develop communication, analysis and critical thinking skills. Discussions will analyze and deepen what has been learned, uncovering nuances that may have been overlooked during the experience.

The different phases thus reinforce each other: knowledge acquired through traditional methods can be re-explored and deepened in the VR/AR environment. Conversely, experiences gained in the environment will be analyzed in groups to deepen understanding, encourage reflection and facilitate peer-to-peer learning.

For example, after being immersed in a historical event, students can analyze primary sources or create their own interpretative content, to contextualize the immersive experience. Similarly, knowledge imparted in a traditional setting can be safely tested in a realistic virtual environment.

3.14. Staying ethical

Respect for ethics involves a series of commitments:

- as in the real world, ensure that content does not spread stereotypes or prejudices, particularly when it comes to discovering other cultures,
- not to collect personal data,
- not to retain data collected by the systems beyond their use in teaching in collaboration with learners,
- propose alternatives to access equivalent training content.

4. Budget and financing

4.1. The costs[4]

Integrating virtual or augmented reality into adult education can require substantial investment, whether you opt for off-the-shelf solutions or develop your own content in the face of a supply that is still inadequate and poorly adapted to didactic needs. Only content developed for leisure purposes for the general public is affordable, even if the acquisition of collective licenses increases costs.

Development costs are relatively high because they involve:

- the involvement of several professionals with complementary skills,
- mastering sometimes complicated software (where human resources are scarce and in high demand) to develop the application and interactions,
- use different media, but making immersive videos and producing quality sound is expensive (you need good equipment, skills and you have to travel for the recordings),
- create 3D objects and, if immersive videos are not used, recreate complete virtual environments in 3D.

The cost of a virtual reality application can vary from 5,000 euros to 100,000 euros, or even much more.

4.1.1 The simplest applications (around 5,000 euros)

Virtual tour of a location

A virtual tour with a virtual reality headset of the equivalent of a three-room apartment, based on photos or 360° videos already shot and edited, including a few explanatory pop-ups in each room to provide an informative experience.

Exploring a 3D object in virtual reality

IHMTEK gives the example of exploring a car engine, where the user would be placed in a white room facing an engine, floating in the air: "*Hand movements could be used to make the engine turn, and some informative pop-ups could explain the different parts of the engine. The user could move around the engine, [...] no complex animation, such as animated disassembly of engine parts, would be included [...] the 3D model of the engine is provided by the customer. The work is limited to programming the interactions and retouching the motor model, as in general, many of the 3D models from CAD software are unsuitable for virtual reality*."

4.1.2 More immersive experiences

A budget of between 12,000 and 15,000 euros (incl. VAT) is sufficient to create a relatively simple virtual reality application lasting around 5 minutes.

[4] This chapter is based on examples provided by IHMTEK - Interactive technologies, to whom we would like to express our sincere thanks.

With this in mind, IHMTEK gives the example of the conversion of a practical session for the Orange training center. A hands-on session covers a specific topic, such as identifying and replacing communication cards, detecting card or server faults, maintenance procedures, etc. The production of a module (TP) involves a conception and design phase lasting around 3 days. Site visits enabled us to understand their environment and capture photos and videos of the elements to be modeled in 3D, such as servers and maps, with Orange also providing photos and videos of procedures for reference. The servers were modeled in 3D, along with a simplified server room, several communication cards and tools. "*The objectives of the virtual reality project were:*

- allow the user to find the faulty server (by moving around the virtual world),

- identify the fault (requiring programming of a specific LED behavior for the anomaly),

- replace the card according to the required procedures (put on an antistatic watch),

- learn to use the appropriate tools, which we had also modeled,

- perform the appropriate actions, such as pressing certain buttons on the server to deactivate the card and remove it, identify the appropriate replacement card, and install it correctly, checking that its LEDs light up according to the specific sequence."

4.1.3 Virtual reality applications (budget 25 to 40,000 euros excl. tax)

IHMTEK illustrates a project of this scale by producing a 15-minute serious game for a training center specializing in air handling unit skills. The game immerses learners in real-life situations using virtual reality, exposing them to potential hazards, operational procedures and professional skills. The project took three months to develop, with the following phases and costs (excluding tax):

- Two weeks of conception and design, including regular exchanges with the customer (approx. 5,000 euros).
- Use of existing graphic resources (3D models of buildings, office furniture, windows, ceilings, etc.) and creation of custom 3D models from photos and videos (air conditioning systems, ventilation systems, air outlets, air handling units, sensors such as thermometers, anemometers, etc.). (approx. 15,000 euros).
- Scripting of training and programming of interaction with measurement tools so that they can vary according to air outlets or inlets, as well as the type of measurement (temperature, pressure, air flow, etc.). (approx. 8,000 euros).
- Programming of a local network system, enabling the trainer to connect to each virtual reality headset via his or her computer to see what the learners are observing, offer help, modify parameters to simulate anomalies or variable conditions (temperature, air circulation) in real time (approx. 10,000 euros).

4.1.4 Consumer applications

To illustrate this category of projects, IHMTEK gives the example of Dinoplagne VR, which came into being following a public tender to showcase the dinosaur footprints discovered at La Plagne. The 3D modeling of all the objects and the precise animation of the dinosaurs in collaboration with scientists to respect the parameters of the Jurassic era (flora, fauna...) was estimated at around 60,000 euros excluding VAT. 360° photos were used to combine the present and the past. Programming (estimated at around 10,000 euros ex-VAT) enabled the cultural mediators to launch the experience in each virtual reality headset, connect additional headsets, monitor the battery levels of the controllers and headsets, and keep track of the time remaining for each experience. The duration of the experience was limited to 6 minutes, with an option of 3 minutes in the event of heavy museum attendance.

4.1.5 Budget of approximately 100,000 euros excluding VAT

This type of experience generally concerns games intended for deployment on headsets or in virtual reality rooms, or projects in the industrial sector. IHMTEK gives the example of a 45-minute virtual reality escape game, Far Worlds, developed for E-reel, with several graphic settings (submarine, medieval environment, space and a cave), puzzles to solve, interactions between players, and other elements.

4.1.6 Use market applications

The offer mainly concerns university and vocational training courses, and is much more limited in French for adult education.

For example, Elsevier offers an annual subscription to the 3D anatomy platform Complete Anatomy, created by 3D4Medical, which enables users to visualize, manipulate, modify and understand the spatial relationships of anatomical structures. In 2023, for a student, the license will cost 39.99 euros for the first year, rising to 74.99. Formulas are available for training centers, including customization, LMS integration and student performance tracking.

4.1.7 Enrich your own courses with augmented reality or immersion

Many commercial software packages come with a free basic version, at least for the education sector, allowing you to test them out and make projects, before eventually upgrading to more advanced features. There is also free open source software.

To create 360° content in the classroom, you need a camera. Good-quality models are available for a few hundred euros (e.g. the *Insta 360*). They come with free editing software and don't require any professional skills to use. However, the trainer will need to invest time in mastering the equipment and software, especially if he or she is new to video or photo editing. After post-production, the video can be uploaded to YouTube, where it can be viewed with headphones. A 360° camera can also be used to take 360° photos, which can then be exported to creative platforms such as ThingLink or CoSpaces Edu.

Tools for teachers and learners

1. ThingLink [www.thinglink.com]

ThingLink is an online tool that lets you create and share interactive images and videos by inserting images, sound, film, text, links and more. By hovering over the insertion points or tooltips, you can make the inserted documents visible and consult them. Easy to learn, the tool can be used by teachers and students alike for presentations, independent study of a situation in history and geography, presentation of an author, an event, a work of art or a historical figure... The basic version is free.

2. Tilt Brush [www.tiltbrush.com]

Tilt Brush is a virtual reality art painting application launched by Google initially on the Steam VR platform, for the HTC Vive headset. Then it was made available for other VR headsets, Oculus Quest and Oculus Rift, Valve Index, PlayStation VR. It lets you create works of art in 3D volume. Immersed in a 360° environment, the user acts using controllers. In 2021, Google abandoned it, leaving it open source.

3. Merge Cube [https://mergeedu.com/cube]

The Merge Cube is a cube, decorated with various symbols. It can be ordered from the official store or elsewhere on the web, or made yourself from the model. It works like a cubic QR Code, with each face recognized by the application used to display part of the 3D model. The Merge Cube can be combined with a number of applications. For example, Object Viewer for MERGE Cube, available on Google Play and Apple Store, lets you load 3D models to display skulls, cells, DNA...

4. CoSpaces Edu [https://cospaces.io/edu]

CoSpaces Edu enables students to design their own immersive worlds, which can then be used for augmented reality and/or virtual reality, with 3D content and simplified code. There are two ways to explore the universes created: in augmented reality with a smartphone, tablet and/or MERGE-Cube, or in virtual reality by visiting the creations in 3D with a CardBoard-type viewer (note that the Google Cardboard software is also available as open source).

5. Increase [www.augment.com]

Augment is an application that generates textured 3d models and displays them in augmented reality using a marker or tracker. It runs on Android or IOS.

5. YouTube VR [https://vr.youtube.com]

The YouTube VR app lets you search for and watch 360° videos and virtual reality content with certain headsets and devices. There are no tools for creating VR experiences. VR playlists suitable for education are available.

6. Google Earth [https://earth.google.com]

Google Earth is a software program that visualizes the Earth by assembling aerial and satellite photographs. You can fly over the Earth and zoom in on the location of your choice. Depending on the geographical region, the information available is more or less precise. You can even obtain a 3D view of buildings in major cities. The three-dimensional modeling of buildings, initially carried out using SketchUp software, is now created automatically using algorithms based partly on Street View shots and partly on altitude data.

7. Google Arts & Culture [https://artsandculture.google.com]

Google Arts & Culture is a service launched by Google in February 2011, enabling visitors to take virtual tours of various museums or cultural and heritage projects, and to view high-definition images in a wide variety of themes. In 2018 *Pocket Gallery* offers virtual gallery tours using augmented reality. Since October 2021, it has been web-based, meaning that virtual tours can be explored on computer and mobile with or without augmented reality capabilities.

4.1.8 Conclusion

Requiring less special equipment, augmented reality is more accessible in an educational context.

If, in terms of development, we can hope to see virtual reality evolve in the same way as corporate websites, for the time being cost containment means writing a relatively simple scenario with limited interaction, lowering graphic quality requirements, using already existing 3D models, and using 360° photos and video.

When the planned investment is substantial, it may be worthwhile to build the project in several sub-modules from a base, and then to build it on an evolutionary basis by adding additional sub-modules, which may be less costly.

While development costs are high, operating costs can be very low. On the user side, most training organizations can afford to invest in virtual reality headsets, with the most advanced costing just a few hundred euros. If you opt for "Cardboard" viewers into which you can insert a smartphone, the cost is negligible, with models ranging from ten to twenty euros, which you can even build yourself.

4.2. Financing

The search for subsidies and partnerships with companies or organizations sharing the same objectives can help reduce the financial burden.

A particularly interesting avenue to explore is the pooling of costs with other training organizations and the support of OPCOs and professional federations for the creation of modules that cut across several initial and continuing training courses, reaching hundreds of learners each year on a regional scale, and thousands nationwide. These modules can be aimed at mastering a professional skill, such as machine-tool operation, or the interpersonal skills required in different contexts, or a business procedure, for example in the field of quality.

The template in the Appendix is designed to facilitate the creation of cooperation between organizations, and to formalize a request to a developer.

5. Checklist for integrating virtual or augmented reality into adult training

1. **Understanding and justification**

- Identify needs: for what purpose do you want to use virtual or augmented reality?
- Do we have a clear understanding of the possibilities? What examples can we draw on?
- Advantages: what will virtual or augmented reality bring?
- What are the limits and what do you need to pay particular attention to?

2. **Planning and resources**

- Identify needs in terms of technical and IT skills, content, hardware and software.
- Choose between buying existing content and creating customized resources.
- Budgeting: what financial resources are available? Is it possible to obtain a grant? Find partners? Join forces with other organizations?

3. **Development**

- If in-house development is possible, build the team.
- If development is to be carried out by a service provider:
  - Drawing up specifications
  - Search for potential service providers based on completed projects (experience in the training field is preferable).
  - Review and selection of proposals
  - Discussions with the service provider during the design and scriptwriting phases
  - Photo and video shoots
  - Validation of the various stages
  - Testing the prototype
  - Validation of the final product.

4. **Preparing trainers**

- Sessions to familiarize trainers who will be using the product
- Ensure that trainers are able to manage interactions, modify settings, support learners and solve basic technical problems.
- Adapt teaching methods to make the most of virtual reality.

5. **Implementation and integration**

- Plan the integration of sessions into the training program.
- Test the prototype's effectiveness with a small group.

6. **Safety and ethics**

- Provide a suitable space.
- Do not store learner data after the end of their training.

7. **Reviews**

- Propose an evaluation that measures what has been learned during the sessions.

- Gather and analyze learner feedback to better integrate sessions.

6. Conclusion

6.1. Why use virtual or augmented reality ?

1. **Experiential learning:** immersed in a virtual environment, learners can have experiences that would be difficult or impossible in a traditional setting.
2. Adult learners can also **explore on their own.**
3. **Flexibility of time and place** to meet the multiple commitments of adults.
4. Opportunities for collaboration and interaction across geographical boundaries.
5. Motivation: the immersive nature of virtual reality can increase participation and interest, even in complex or tedious subjects.
6. **Simulation realism**
   - **Environmental nuances:** Virtual reality lets you capture nuances, such as the background noise of a coffee shop for barista training, pressure and temperature changes during diving, or patient signals in a medical diagnosis.
   - **Multisensory feedback:** in addition to visual and auditory experiences, virtual reality can offer haptic feedback by creating tactile sensations. For example, a mechanic can feel the resistance of a bolt, and a surgeon the texture of a fabric.
7. **Greater access to tools and equipment:** with a virtual toolbox, you can practice with a wide range of tools, without necessarily having them to hand.
8. **Risk elimination: the** consequences of costly or dangerous errors can be simulated, whether a short circuit due to incorrect wiring, or a motor malfunction due to incorrect assembly.
9. **Scenario-based learning**
   - **Variable difficulty:** introducing variability into scenarios enables them to be adapted to different levels to develop problem-solving skills.
   - **Immersive role-playing: you** can simulate a wide range of characters and personalities to practice dealing with different types of customers or patients.
10. **Targeted skills enhancement**
    - **Detailed performance analysis: by** recording precise information, such as hand stability during a delicate task, reaction time in a crisis scenario, or eye movements and concentration points during an activity.
    - **Adaptive difficulty levels: as** the learner progresses, the system can increase the difficulty of tasks, for continuous skill development.
11. **Enhancing non-technical skills**
    - **Emotion recognition:** advanced systems can assess emotional states through facial recognition and adapt scenarios accordingly.
    - **Communication assessment:** by analyzing voice modulation, elocution and body language, to fine-tune presentation or negotiation skills.
12. **Integration with reality**
    - **Hybrid scenarios: for** example, training for IT staff in a virtual environment, but where the data they are working on is real.

- **Real-time remote collaboration:** an employee can work on a machine in France, while an engineer in Germany assists him via an augmented reality interface, guiding him on the machine he can see.
- Virtual reality develops empathy for people in difficult situations by enabling them to partially share their point of view.

13. **Evaluation:** behavioral monitoring highlights the areas in which a learner excels and those in which he or she needs further training.
14. **Respect for the environment:** by eliminating the impact of forming, the process is sustainable and respectful of the environment, notwithstanding the impact of digital technology.
15. When learners create their own content in virtual reality, it helps develop digital **skills** and **creativity**.

Virtual reality offers a depth and breadth of experience unmatched by traditional methods. For refresher or advanced courses, this realistic, immersive gateway to real-world application can make the difference between knowledge and mastery.

6.2. Challenges

1. **Accessibility and costs**

- The cost of developing realistic, highly interactive scenarios can be a deterrent.

Buying turnkey products limits investment. Less ambitious scenarios are also possible. Collaborating with companies, seeking subsidies and, above all, teaming up with other training organizations can help mitigate cost issues.

2. **Digital literacy:** not all adults are comfortable with these technologies, and some won't want to participate. User-friendly interfaces with intuitive controls and introductory sessions will help get more people involved.

3. **Content creation**

- **Quality** must come first, even if it's tempting to produce a lot of scenarios. Poorly conceived, unrealistic content with limited interaction reduces effectiveness and can even be counter-productive by giving the impression of infantilizing learners.
- In virtual reality, it's important to avoid including scenery elements that could become obsolete after a few years of use.

Collaborative development involving content experts, trainers and developers is more likely to generate attractive, instructive scenarios.

4. **Ethical implications**

- **Personal data**: will not be kept after the training session and cannot be used by third parties or for commercial purposes.
- **Representation and inclusion:** Modules must offer diverse representation in avatars, scenarios and content. Prejudice and stereotyping must be avoided.

- **Serenity:** the virtual space must of course be free from harassment, intimidation or any form of discrimination.

5. **Health and well-being**

- **Physical problems:** the use of these technologies is not recommended for people suffering from epileptic seizures. Prolonged use can lead to eyestrain, headaches, dizziness, disorientation or motion sickness.
- **Mental balance:** there is a risk of disruption for people with mental or psychological disorders. Some may find it difficult to distinguish between the virtual and the real, with simulations that can have an emotional impact.

User selection and clear guidelines on duration of use and the need for individual headset adjustment can alleviate many of these concerns.

Despite the many advantages of virtual or augmented reality in adult education, if it is being deployed only very slowly, with a few advances but mostly periods of stagnation, it seems to be because of the high cost of applications that really add value, or the considerable preparation time that even the most technophile teachers have to devote to enhancing a few demonstrations with augmented reality.

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Wikipedia

8. Appendix
Expression of need /[5]

1. Purpose of the immersive learning module

Module-specific information

1.1 Challenges

Importance of the immersive teaching module for the business sector, the skills involved, the reasons for choosing it and the trades concerned

1.2 Contributors to the immersive learning module

List of contributors to the creation of the module

1.3 Targeted training

1.4 Potential scope of supply

Number of learners potentially concerned

1.5 Pedagogical objectives

Pedagogical objectives of the module and contribution of technology

2. Expression of pedagogical need

2.1 Scenario / Mode

Precise description of the scenarios to be digitized (scenario, learner role, actions to be carried out, sequence of actions, etc.).

2.2 Components to be modeled

All elements expected in the module

2.3 Expected interactions within the tool

List of possible learner interactions in the module: objects, documents, people, etc.

2.4 Valuation

Criteria for assessing whether or not the learner has achieved the defined learning objectives.

2.5 Level of learner guidance

Choice of level of support and assistance for the learner in the module (avatar guidance, visual aids, etc.).

2.6 Terms of use of content

Modes of use: face-to-face/remote, synchronous/asynchronous

2.7 Data to be collected from the immersive experience

Elements to be collected in the module that can then be passed on to the learner or trainer during and at the end of the simulation.

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[5] This appendix has been adapted from the Guide méthodologique *Digitization de modules pédagogiques immersifs transverses* proposed by the Ministère du travail, du plein emploi et de l'insertion.

2.8 Customization and content creation

Level of customizability of the immersive learning module (changing logos, adding information, etc.)

2.9 Typical user profiles

Learner profile, trainer profile, administrator profile.

2.10 Graphic and editorial lines

2.10.1 Expected level of graphic precision

Expected level of graphics to best reproduce a real-life work situation

2.10.2 Languages

Module languages and translation methods (voice-overs, subtitles, etc.)

2.11 Potential extensions and evolutions

Potential extensions or evolutions of the module (new scenario, variation of certain elements, update of the environment, etc.).

2.12 Documents for learners

Documents to be given to the learner at the beginning or end of the simulation (additional resources, etc.).

2.13 Resources for service providers

Elements for service providers to help them create the module (business experts, documentation, 3D plan, etc.)

3. Expression of technical need

3.1 Access

Technologies on which the module should be accessible (computer, tablet, smartphone, VR headset, AR headset, etc.)

The scenarios should be accessible on a variety of media, in 2D on computers, phones and tablets, and in 3D on virtual reality headsets. Headsets should preferably be wireless. In addition, the immersive environment should be as transverse as possible, so that it can be used on different types of headsets.

3.2 Accessibility

Module accessibility requirements

For example, video subtitling, enhanced color contrasts, etc.

3.3 Hosting arrangements

Content and application hosting in the European Union.

3.4 Operational service levels

3.4.1 Access range

Module access ranges: infrastructure availability, service opening times, etc.

The host of the content produced must meet the following minimum requirements:

- Service hours: 24 hours a day, 7 days a week

- Infrastructure availability: 99.9% of the time over one year.
- Service guarantee range: working hours (5 days a week from 8am to 6pm).

3.4.2 Number of users

Number of users during test phase and general *availability*

3.4.3 Environment availability

Inaccessibility requirements: incidents and associated penalties

<u>3.5 Protection of personal data</u>

Data *protection requirements*

Compliance with the RGPD and Law no. 78-17 of January 6, 1978 relating to information technology, files and freedoms, amended by Law no. 2018-493 of June 20, 2018 relating to the protection of personal data.

<u>3.6 Evolution of the immersive environment</u>

Evolutions required to adapt the module to new requirements or new technologies.

The service provider may be asked to develop one of the following elements within 4 years of creating the immersive environment:

- Educational content: backgrounds, characters, scenario, etc.
- Compatibility with new browsers or headset types, etc.
- Create or update new LMS connectors

<u>3.7 Intellectual property</u>

Intellectual property requirements to be defined for each module

4. Expected services

<u>4.1 Proposed technology</u>

Technology envisaged for this module (virtual reality, serious game, conversational agent, etc.)

<u>4.2 Description of services</u>

Expectations of the editor in terms of project management, application construction, solution deployment and testing, content updating, skills transfer, etc. :

- Project management
- Application construction
- deployment and testing of the solution, with connections to existing LMSs and support for trainers in getting to grips with the tool and its use in a training course, content customization, maintenance and cleaning of Virtual Reality headsets, before proposing a final version of the content.
- Access to and updating of content, including hosting for n years, preventive, corrective and evolutionary maintenance to ensure that content functions correctly on different equipment (virtual reality headsets, browsers, etc.), graphic updates or content scenarios at the request of the organization, and the production of an accompanying guide.

- Advice and expertise throughout all phases.
- The transfer of skills to the teams responsible for administering and operating the solution.

4.3 Deliverables

The list of deliverables includes project management (reports, incident tracking, etc.), tool design (technical architecture, detailed functional specifications, etc.), the various iterations, hardware requirements, training kits for different user profiles (trainers/teachers and learners), simplified operating procedures for hardware installation (tutorials, etc.).

4.4 Warranty and maintenance

Creative Teaching
through Virtual Reality

CT:VR - Creative teaching through virtual reality
Erasmus+ project n° 2021-1-ES01_KA220-000033619

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