PROJECT

VIRTUAL REALITY EDUCATION

by
Alessandro Innocenti
LabVR UNISI, University of Siena
http://www.labvrunisi.it/
(October 2022)

1. Introduction

The problems posed by the health emergency prompted universities and educational institutions to initiate a process of change that led to the experimentation of all innovative digital technologies to support teaching. In this perspective, which has actively involved all levels of our educational system, special attention has been paid to the combination of Virtual Reality (VR) and Artificial Intelligence (AI), which offers numerous opportunities in many subject areas for the innovation of educational methodologies and learning systems. In fact, its characteristics of immersiveness, interactivity and multi-sensoriality appear capable of enabling a radical change not only in the distance enjoyment of educational content, but also of profoundly transforming classroom teaching, fully realizing the inverted classroom model (flipped classroom), taking advantage of the availability of advanced digital content to enable students to acquire knowledge independently and then deepen it in the classroom through shared experiences with the teacher. With this in mind, the University of Siena's Virtual Reality Laboratory launched the EL-VR pilot project in 2022 to create VR teaching tools.

2. The EL-VR Project

The EL-VR project aimed to create Virtual Environments to support educational innovation with the purpose of implementing the "flipped classroom" pedagogical model. The activity carried out led to the creation of VR simulations deliverable in courses in the academic year 2022-2023. These simulations were built around the idea of interactivity and sequentiality of exposure and represent a digital tool for the student for self-education. By taking advantage of the high level of interactivity and immersiveness in multiplayer mode, the student has the opportunity to get involved, deepen and then learn at his or her own pace a number of fundamental notions and then share them in class with the teacher and other students.

The basis of the implemented experiences is the context in which the user's senses are effectively stimulated by the digitally reproduced artificial stimuli. To date, visual and auditory stimuli have been administered, but kinesthetic and tactile feedback will also be possible in the near future.

The environments or contexts used for a lesson are 3-D modelled environments or reproductions based on 3-D drawings produced by a technical artist. The advantage of this approach is its extreme versatility, allowing digital content to be reproduced at simplified resolutions and thus in shorter time. Environments acquired by 3D scanning and photogrammetry have also been reproduced, which now allow for rapid results with very high graphic quality. For example, at an archaeological site, complex and irregular natural objects were scanned with dedicated devices (3D scanners) or reconstructed from photographs (photogrammetry).

Virtual environments contain the objects in the lesson, also modelled three-dimensionally or acquired by scanning. During modelling, the different parts were placed in hierarchical relation to each other, allowing subsequent automatic framing and isolation of parts to which multimedia and didactic elements could be added. In addition, the various parts that make up an object were "exploded" and "reassembled" automatically or manually, allowing for high interactivity. Again using three-dimensional geometry, a variety of animations illustrating mechanical, biological, or logical processes were possible. For the student to observe in motion the interaction of the various parts, from various viewpoints, is an increasingly effective educational possibility than static sequential images.

Each identified and classified part of the lesson object has also been enriched with supporting multimedia elements that allow essential or optional insights. The virtual space naturally lends itself to the appearance of other images, videos, text and the simultaneous playback of voice notes that have been distributed along the way.

The second phase of the inverted classroom model was implemented using one of the most interesting possibilities of multiplayer virtual environments: being able to collaborate in the same space, either remotely or in presence. The teacher can frame and visualize each element during the lesson, while students immersed in the same experience have perception of its location and the focus of its actions. The lecturer can grant control in turn to students, require them to perform precise actions and answer pre-set questions or quizzes.

The same mode of fruition can be applied by introducing an avatar that, by adopting machine learning software, dialogues with the student, making it interactive with the training content.

The simulations created are available on the platform made available to the University of Siena by Simula srl and covering the following courses:

- For the teaching of Archaeology, a pilot simulation was created in which it is possible to explore an archaeological excavation (Poggio Bonizio) and acquire some information about the finds and the history of the place. The storyboard of the simulation was made in collaboration with the Department of Historical Sciences and Cultural Heritage.

- For the teaching of Biology of Human Reproduction, a simulation was made reproducing the laboratories of the Department of Molecular Medicine that can be used for teaching the course in an interactive mode. The storyboard of the simulation was made in collaboration with the Department of Molecular Medicine.

- Two simulations were carried out for the teaching of Applied Biochemistry, one reproducing the laboratory activity leading to DNA extraction and the other the polymerase chain reaction (PCR). The simulation storyboard was carried out in collaboration with the Department of Biotechnology, Chemistry and Pharmacy and the VitaLab Joint University Laboratory.

- For the teaching of Human Anatomy, "Oxistress" an educational science popularization game in VR was created, developed in collaboration between the Department of Social, Political and Cognitive Sciences and the Department of Molecular and Developmental Medicine. Through storytelling and gaming, the project disseminates research findings investigating the relationship between dietary fatty acids and male fertility.

Lectures in VR will be delivered during the academic year 2022-2023 to students attending bachelor's and master's degree programs in the indicated disciplines through Quest 2 virtual reality helmets. In addition, as envisaged in the research program, video and graphic materials are available to students and faculty to deepen and supplement the lectures delivered in virtual didactics, slides and images useful for the construction of course content that stand as supplementary material to what is delivered in VR. The courses can be enjoyed in synchronous and asynchronous mode, while all study materials can be enjoyed in asynchronous mode.

3. FUTURE DEVELOPMENTS. A PRACTICAL EVALUATION

This pilot project demonstrated the potential of VR to the teachers and students involved in the tests. The advantages of virtual reality in education are appreciated by many teachers, but some are still reluctant to use it in their classrooms. The reasons range from high costs to resistance from school administrators. Others see the value of VR as entertainment, but not as effective teaching tools in the classroom. Other concerns of teachers include equipment clutter, operating problems, and the quality and availability of content. Despite these challenges, it is easy to predict that the use of VR in education will grow in the coming years. This implies that current and aspiring teachers will have to become familiar with virtual reality and how to use it in the classroom. This process requires a careful evaluation of the costs and benefits of the introduction of VR in our education system also in view of the investments that will have to be made to enable its rapid and effective implementation.

3.1 Hosting and delivery platform

Building and administering a hosting and delivery platform is essential both to allow users to download and run simulations via the viewer and to meet the needs of tracking and scoring courses in VR. This amounts to creating a true metaverse, which requires radical changes in the methods adopted by universities or educational institutions in teaching and learning. Indeed, the combination of VR and AI technologies based on immersive environments must be adapted to the student's abilities and interest by making teaching less structured, with more flexible rules allowing for immersive and interactive enjoyment. For example, students in the metaverse are not only recipients of content, but active participants in VR simulations. This approach requires significant changes not only in teaching but also in evaluation and monitoring processes. Traditional tools such as examinations or written or oral tests are not appropriate to assess the individualised and unstructured learning experiences offered in the metaverse. Through the platform, a wide range of virtual simulations can be delivered that include already used learning tools and others that are completely innovative:

- Learning courses based on learning by doing

- Virtual field trips

- Peer-to-peer meeting spaces

- Shared face-to-face training courses

- 3D visualisations

- Personalised learning experiences

- Accessible learning experiences for people with physical disabilities

- Recruitment tools for universities

- Administrative and departmental meeting spaces

In the US, more and more colleges are becoming 'meta-universities', bringing their physical campuses into an online virtual world. An initiative funded by META, Facebook's parent company, includes 10 US colleges and universities who, in collaboration with VictoryXR (https://www.victoryxr.com/), have created 3D replicas, called 'digital twins', of their campuses that are updated in real time with the people and objects moving around the real campus. At some of these universities, classes are already accessing the metaverse and VictoryXR says it plans to build and operate 100 digital twin campuses by 2023, enabling collective use with live instructors and real-time class interactions. Another metaversity developer, New Mexico State University, has planned to offer degrees where students can take all classes in virtual reality starting in 2024. However, creating a metaverse is not necessarily an expensive task to carry out from scratch, considering that among the available resources there are applications that are accessible at low or even free fees, such as 360Cities (https://www.360cities.net/), which allows students to visit cities such as Rome and Tokyo, and TimeLooper (https://www.timelooper.com/), which allows students to study history by visiting cities in the Middle Ages or during World War II, or versatile platforms such as Immersive VR Education (https://immersionvr.co.uk/) and Nearpod (https://nearpod.com/), which allow teachers to create educational programmes in VR. There are also a number of popular virtual spaces on the web, with which a purpose-built metaverse can be easily integrated:

- AltspaceVR (https://altvr.com/), a social platform operated by Microsoft that enables meetings with people from all over the world and participation in private or public live events.
- Bigscreen (https://www.bigscreenvr.com/), an immersive social computing experience that allows physical computers to be used in VR.
- ClassVR (https://www.classvr.com/it/), the first virtual reality software designed specifically for schools, providing teachers with everything they need to deliver lessons in VR.

- Engage (https://engagevr.io/), a platform for corporate education and training in VR.
- NeosVR Metaverse (https://neos.com/), a highly collaborative virtual and augmented reality metaverse.
- Mozilla Hubs (https://hubs.mozilla.com/), allowing users to share a virtual private room in which to watch videos, play programmes or 3D objects in a multiplayer environment.
- Oculus Rooms (https://www.oculus.com/experiences/), customised VR home that allows people to play games, watch films, listen to music, read books and share photos.
- Rec Room (https://recroom.com/), social network in VR where it is possible to have social relationships and build games with other users.
- Roblox education (https://education.roblox.com/), which allows building learning experiences designed for exploration, investigation and experimentation.
- Rumii Doghead Simulations (https://www.dogheadsimulations.com/rumii), a collaboration tool used for training and education in VR.
- Sansar (https://www.sansar.com/), virtual world created to replace Second Life for playing, creating and exploring.
- Somnium Space (https://somniumspace.com/), open VR world modelled entirely by users in which to trade or import objects and games.
- VRChat (https://hello.vrchat.com/) , which allows users to create, publish and explore virtual worlds with other people from all over the world.

3.2 Teacher training

The main challenge in building a VR education programme is not to equip institutions with these new technologies. While VR is already in use in university and school education in the United States, in Italy VR has yet to become a familiar tool to those working in the educational system. Although the perception that VR offers valuable learning opportunities for disciplines that are traditionally difficult to teach in a textbook is widespread, we are still in the initial phase of communicating and sharing the potential of the tool and therefore need to be addressed with adequate resources and programmes.

Training teachers and academic and educational institutions to incorporate virtual environments and simulations in the classroom is perhaps the most difficult task to tackle at this stage. The first step is to provide educators and students with a virtual classroom, enabling them to connect with consultants, trainers and entrepreneurs. In this training space, which can be created in the virtual spaces listed above, teachers need to be able to explore the use of virtual technologies in education. Each platform offers a unique set of features for educators, entrepreneurs, creators and students to discover, and allows them to create and customise the space, using libraries of templates, images and videos, or to create real-time digital tools to support teaching. This programme requires an investment in specialised teaching staff to provide future teachers in VR with the necessary skills to tackle this endeavour in a multidisciplinary manner.

The training course should address the use and implementation of the teaching platform used. For each teacher involved in the training there should be 4 modules:

- Training module on the technologies and platform used to foster and improve DAD in virtual reality.

- Module aimed at acquiring the digital skills needed to use the platform both to deliver courses and to produce and archive teaching materials.
- Module dedicated to the application of what has been learnt in the classroom directly on the platforms and within the systems that will be used in DAD.
- Final module of sharing and confrontation between all the teachers who took part in the course to exchange ideas and feedback useful to increase the impact of the course and the active involvement of students

The course should alternate between lectures in the virtual classroom and group or individual work in which the lecturers involved will create a DAD project from the definition of the content to its translation for delivery via the platform.

3.3 Privacy, security and data protection

The business models of companies developing technologies in the metaverse are based on the collection of detailed personal data of users. For instance, people wishing to use Meta Quest 2 virtual reality visors must have Facebook accounts. VR helmets can collect highly personal and sensitive data such as location, students' physical characteristics and movements, and voice recordings. Meta, the manufacturer of the Quest helmets, has not promised to keep such data private or limit the access advertisers might have to it. Meta is also working on a high-end virtual reality viewer called Project Cambria, with more advanced features. Sensors in the device will allow a virtual avatar to maintain eye contact and create facial expressions that mirror the user's eye movements and face. Such data information can help data owners measure users' attention and target them with personalised advertising. Professors and students cannot participate freely in class discussions if they know that all their moves, speech and even facial expressions are being watched by the university and a large technology company. The virtual environment and its equipment can also collect a wide range of user data, such as physical movement, heart rate, pupil size, eye opening and even emotion signals. Cyberattacks in the metaverse could even cause physical harm. Metaverse interfaces provide input directly to users' senses, thus effectively tricking the user's brain into believing that the user is in a different environment (sense of presence). Metaverse can also expose learners to inappropriate content. For example, Roblox launched Roblox Education to bring 3D, interactive and virtual environments into physical and online classrooms. Roblox claims to have strong protections to protect everyone, but no protection is perfect and its metaverse involves user-generated content and a chat function, which could be infiltrated by predators or people posting pornographic or illegal material. This problem needs to be addressed in advance at the level of the educational institution or university.

3.4 Infrastructure

Bandwidth. Many applications in the metaverse such as 3D video require a lot of bandwidth. They require high-speed data networks to handle all the information flowing between sensors and remote users in virtual and physical space. Many users, especially in non-urban areas, lack the infrastructure to support the streaming of high-quality digital content. The full operation of the 5G network will solve these problems

Security. To reap the benefits of virtual reality in education, it is important that students use VR equipment safely. VR users often turn or walk blindly, ignoring their physical surroundings. A misstep could result in injury. Teachers must ensure that the physical environments of their classrooms are spacious and safe for VR experiences. Students should stay at least an arm's length away from each other and objects in the classroom. If possible, it is preferable to use VR content accessible to students seated at their desks.

Duration. In general, it is necessary and moderate to use VR in the classroom. Research on the psychological impact of VR on students suggests that the use of VR in schools should be moderated and under close supervision. Results report that users who made excessive use of VR had false memories of physically visiting a place they had never actually visited. Limiting VR sessions to a few minutes within a longer lesson plan may solve this problem. The principle to be applied is that VR cannot replace human interaction. Learning is fundamentally a social experience, so VR is best used as a complementary learning tool.

Programming. Among the most obvious advantages of virtual reality in the classroom is its ability to stimulate students' curiosity and interest. But if left to their own devices, students can easily stray from the path laid out by the teacher. For this reason, teachers should develop a structured plan to maximise the use of VR within lesson plans and guide students along the path. As part of the plan, it is important that teachers determine the goals and expectations for students and set guidelines to be followed to ensure optimal learning experiences in the design and planning phase of virtual simulations.

Social VR. VR is already having a huge impact on social relationships through the platforms listed above that provide virtual meeting and collaboration spaces. These meeting rooms can allow the teacher to monitor and have a class of 20 to 30 students interact in virtual environments. But one of the most important features of VR is the ability to talk freely with others as if they were present in the same physical space. Chat rooms and social platforms can foster social interaction between students without resorting to video-conferencing connections or dedicated physical spaces.

3.5 Costs

Software. The metaverse provides a low-cost alternative for many needs in this project. For example, building a complete laboratory for anatomy courses costs tens of thousands of euros and requires a lot of maintenance and constant updating. One such laboratory was made affordable at Fisk University (https://www.fisk.edu/university-news-and-publications/fisk-university-htc-vive-t-mobile-and-victoryxr-launch-5g-powered-vr-human-cadaver-lab/). Typically, however, licences for digital VR content or the construction of virtual environments add up to costs that are affordable for universities or schools. A single module, such as those realised within the EL-VR project, employs human resources in design, planning and modelling at a cost of 20K/30K, which has to be multiplied by the number of courses activated in VR. It should be emphasised that the simulations created can be used in similar courses at different universities or schools with a clear reduction in unit costs, provided VR simulations are created in the design and planning phase that can be easily adapted to the needs of the individual lecturer. The delivery of simulations through a hosting and delivery platform, such as the one made available by the University of Siena for the EL-VR project, costs between 5K and 30K per year depending on the number of users and the institutions involved.

Hardware. The cost of the hardware is represented by the purchase of the VR helmets currently used by the LabVR UNISI, Meta Quest 2 128 GB version, which cost 449 EUR each (VAT included). The management and maintenance of a large number of helmets and pre-delivery assistance entails additional costs and operating time quantifiable in 2/3 units of full-time or part-time junior staff depending on the number of university or educational institutions involved.

Training. Universities and educational institutions have to devote resources to teacher training on VR technology and VR education. The cost is equivalent to that of organising a university master's course for 25/30 participants (40/50K), multiplied by the number of teaching staff involved, to which must be added the costs of using a laboratory equipped with the necessary hardware (PCs, tablets, VR helmets).

*****