Metaverse-Based STEM Education for a Sustainable and Resilient Future

2023-1-FR01-KA220-SCH-000151516

Work package n°2 - Framing: M-STEM Pedagogical Strategy – Chapters

Chapter 3 Creating Immersive and Interactive Learning Experiences

By EURASIA

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2023

Introduction

Today students are born into a digital world and technology is an inseparable part of their lives. Therefore, today's students find it difficult to respond to traditional education methods. In other words, the digital lifestyles of young people cause traditional education methods to blend with technology and transform according to new needs. To meet their needs, education is shifting from passive knowledge acquisition to active participation. Because today's generation needs new pedagogical approaches. Educators must keep up with this change and integrate technology into the classroom. Using virtual reality classrooms is one of the most effective ways to achieve this.

Immersive learning has emerged as a strategy that uses virtual reality technology to deliver engaging and dynamic learning experiences. Immersive learning replaces traditional lectures and textbooks with simulated virtual environments, 3D simulation of the real world, and group interactions, allowing students to explore, experiment, and produce knowledge in a dynamic and engaging way. This new opportunity led to a change in our understanding of education and changed our perspective.

Immersive learning can involve the application of different strategies. These include gamification, story-based learning, video-based learning or scenario-based learning, branching simulations, Augmented Reality (AR), Virtual Reality (VR), Extended Reality (XR) and Mixed Reality (MR).

Virtual Reality (VR) refers to a fully simulated digital environment in which users are immersed using VR headsets to create believable experiences. These experiences can be a real-life situation or a creative, imaginary experience.

Augmented Reality (AR) combines digital content on top of the real world through a phone, glasses, or a headset.

Mixed Reality (MR) mixes digital and real objects. Users can interact with each other in real time. In MR, virtual objects are integrated into the real-world environment for completely realistic experiences.

Extended Reality (XR) refers to the coexistence of integrated real and virtual environments and human-machine interactions. In other words, AR, VR and MR coexist in Extended Reality.

What is Immersive Learning

Virtual Reality is a computer-generated simulation of a three-dimensional environment. Users can interact with this three-dimensional environment using specialized hardware such as VR headsets or controllers.

VR technology blurs the lines between the physical and virtual worlds and immerses users in a realistic experience. This immersive environment created using VR allows students to feel the virtual environment and its objects as real.

How can you design an interactive learning experience with VR

There are different types of immersion.

- Sensory
- Spatial
- Tactical
- Strategic
- Imaginative
- Social

It would be a good idea to use several of these immersion types together to create an effective immersive learning space. Multiple use of immersion will help users to engage more in the target subject. Of course, the type of immersion can be chosen in line with the pedagogical approach and the requirements of the topic, however, sensory and spatial immersions are the most engaging ones for users. The following graphic provided by C. Wagner and L. Liu (Liu et al. 2017) clearly shows the learning cycle through the immersive learning environments.
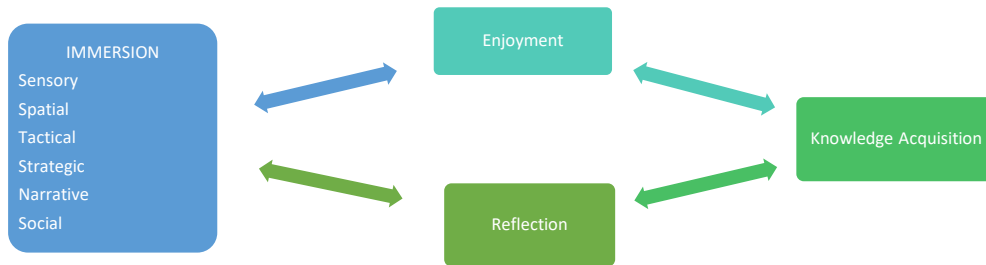
Figure 1 The learning cycle through the immersive learning environments

Designing Immersive Learning Experiences

While designing an immersive learning experience its important to know the types of immersion. As it is previously mentioned there are different types of immersion and the teacher or the designer should choose the most relevant and engaging type to facilitate knowledge acquisition.

In the simplest terms, virtual reality immersion is the feeling that a person is physically present in a virtual environment. Graphics and sounds can be used to create this feeling. Other sensory feedback can also be used, such as the vibration of hand controllers when one's avatar touches an object in the virtual environment or the scent of the environment.

Types of Immersion:

1. Sensory Immersion: Sensory immersion allows users to feel themselves in an immersive environment by using tools that appeal to our senses, such as graphics and sounds. With sensory stimulation targeting your senses of sight, hearing, touch, smell and taste, it allows you to feel yourself in a real environment.

2. Spatial Immersion: Spatial immersion refers to the type of immersion triggered and sustained by the spatial qualities of the virtual environment (Zhang, C. et al 2017). In spatial immersion, the immersive effect of the virtual environment can be achieved by manipulating different spatial elements of the scene. Fast zooming in and out, suddenly changing camera angles may help to create spatial immersion feeling.

3. Tactical immersion: "Tactical immersion is experienced when performing tactile operations that involve skill. Players feel "in the zone" while perfecting actions that result in success".

4. Strategic immersion: "Strategic immersion is more cerebral, and is associated with mental challenge. Chess players experience strategic immersion when choosing a correct solution among a broad array of possibilities".

5. Imaginative immersion: Another way to dive into your imagination is to become emotionally connected to the story or characters you are creating. This is like really getting into a film or book. You can imagine yourself in the place of a character in the film or story and get excited, scared, sad or happy, as if you were the one experiencing all the action.

6. Social Immersion: It means actively engaging with a social group or community that you would not normally be part of. Many universities and educational institutions offer social immersion programmes specifically designed to educate students about certain social issues.

What are the elements of Immersive Learning Experiences of MSTEM course

As it is mentioned earlier, the key to a successful Immersive Learning Experience design lies in choosing the right type of immersion and implementing it effectively. For MSTEM we will use sensory, spatial and social immersion types. The graphic below shows the structure and Immersive Learning Experience elements of MSTEM course.
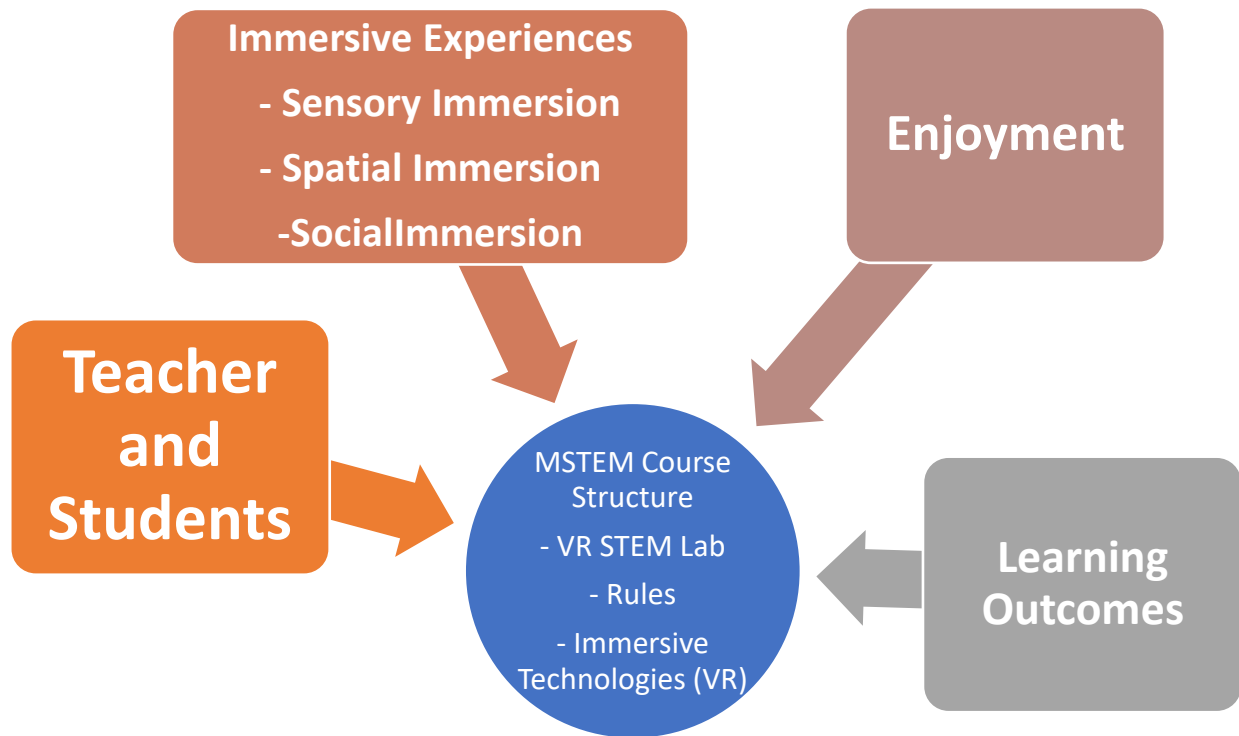
Figure 2 Immersive Learning Experience elements of MSTEM course

VR STEM Lab as an Interactive Learning Environment

MSTEM VR Lab will be our main interactive learning space. Different elements will be used to create an interactive learning environment in MSTEM VR Lab. These elements will be supported by different elements to create a sense of sensory, spatial and social immersion. Here we will go through these elements one by one.
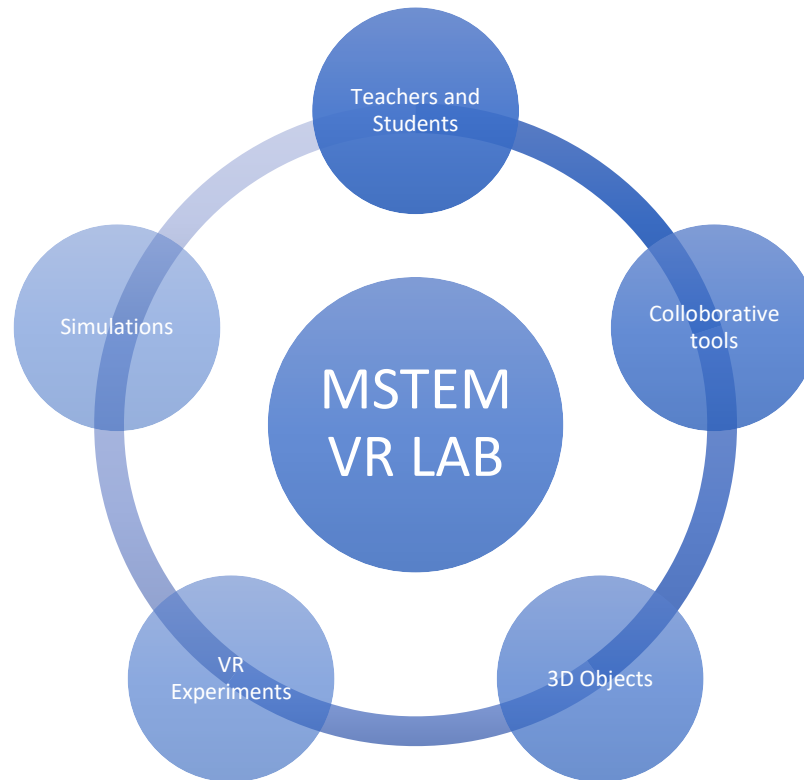
Figure 3 The elements of MSTEM VR LAB

STEM Lab Environment for sensory immersion and spatial immersion

MSTEM VR Lab will include some immersive elements to create sensory immersion feeling. A 360 degree space where the students can observe their environment will make them feel in a real lab and interacting with objects using VR gears will stimulate their sense of touch. Visual aids will also be used to appeal to the visual senses. 3d models of STEM objects can be presented by the teacher and the students will interact with these objects.

Collaborative Tools for social Immersion

The MSTEM VR LAB also supports students to interact and work in groups. Under the supervision of the teacher in the VR LAB, students will be able to work collaboratively on a project, experiment or simulation and act together while completing a task. This will create social immersion.

Simulations

Simulations of STEM experiments will support the sense of reality. With the help of experiment simulations, students can have the opportunity to experience scenarios that they cannot experience in real life. For example, an experiment that can be performed in a non-gravity environment can be easily performed in VR STEM Lab. By controlling gravity, students can observe the living conditions on different planets. Another simulation example is that experiments that need to be done in a time-dependent manner (such as fossilisation process, water cycle) can be carried out in a short time in VR STEM Lab. All these elements will enable the student to enjoy the process and encourage the student's active participation in the lesson.

In MSTEM VR LAB students can visit other planets or galaxies, climb the mount Everest or explore the ocean. Possibilities are limited to your imaginations.

The VR Experiments

MSTEM VR LAB allow students to do many experiments. Students spend less time to do Simulated VR experiments than they spend for physical ones. VR helps students to learn more about the STEM topics in a 3D environment. This kind of learning settings

Virtual classrooms facilitate access to experiments and applications that are normally difficult to see physically. Experiments that require a long time to finalise and can be done by creating special environmental conditions can be easily done in a VR environment.

There are some advantages of conducting STEAM experiments in VR environments. Students can repeat the processes until they fully understand the process and excel

at the targeted skill. Unlike physical experiments, VR experiments prevent students from being harmed. Physical damages that may occur as a result of incorrectly conducted experiment processes are prevented.

The 3D objects provided and the use of simulations in the experiments, which offer the possibility of detailed examination, enable students to realise the exact skill to be taught. The MSTEM VR LAB environment, which offers the opportunity to work as a team throughout this whole process, allows students to complete the learning process by having fun.

Conclusions

Immersive learning, powered by virtual reality, revolutionize education by taking students beyond the limits of textbooks and classrooms. With the ability to use multiple immersion types – sensory, spatial, social, and more – VR environments create compelling experiences that engage learners on a deeper level.

Key aspects of designing immersive learning experiences are understanding the different types of immersion to implement them effectively within MSTEM courses. The MSTEM VR Lab is a great example of how sensory immersion through 3D environments, spatial immersion through interactive elements and social immersion through collaborative tools can be combined to promote deeper understanding and engagement.

By utilising the power of virtual reality, we can unlock a universe of possibilities in education. Imagine students conducting complex experiments on distant planets, climbing the peaks of Mount Everest or diving into the depths of the ocean - all within the safe and accessible setting of a virtual classroom. Only our imagination sets the boundaries. MSTEM VR LAB can unlock the full potential of learning in the virtual age.

We cannot ignore the transformative potential of immersive learning. This innovative approach should be embraced by teachers and educators.

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Useful Links: