Metaverse-Based STEM Education for a Sustainable and Resilient Future

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

Chapter 1 Introduction to the M-STEM Pedagogical Strategy

By EURASIA

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Introduction

MSTEM Pedagogical Strategy is a learner-centered approach to immersive learning, facilitated by teachers and powered by technology. Immersive learning goes beyond traditional lectures and textbooks. Students actively explore and build knowledge through simulated environments and real-world interactions. Learners experience familiar and unfamiliar scenarios in a safe virtual space. This overcomes limitations like distance, danger, or cost, making impossible experiences possible. Teachers design the immersive environment alongside students, setting goals and assessing progress within the virtual world. They act as guides, not dictators, fostering learner autonomy. Students choose their pace, content, and learning strategies, while teachers provide guidance and ensure alignment with learning objectives. This promotes self-directed learning and ownership. Different types of immersion cater to diverse learning styles and preferences. Enjoyment is key, as it fuels engagement and deeper understanding. Collaboration and dialogue among learners remain crucial for knowledge construction and refinement, even within immersive environments. Technology like virtual reality and simulations bridge the gap between teacher-designed structures and student knowledge construction, providing tools to maximize cognitive potential. Immersive learning prioritizes experiences that are fun and engaging. When students enjoy the process, they learn more effectively and develop valuable skills. Immersive learning is not just about fancy technology; it's about creating a learner-centered environment where students actively engage, explore, and construct knowledge.

Wagner, C., & Liu, L. emphasizes that immersive learning breaks away from traditional models and places emphasis on active engagement. Learners are not just passive recipients of information, but actively explore and construct knowledge through interactive experiences. While drawing the framework of immersive learning, the experts emphasize the following features:

- Learners are placed in simulated environments that replicate real-life situations, making it possible to experience the familiar and unfamiliar in a safe and controlled setting. This allows for learning that wouldn't be possible otherwise due to limitations like distance, danger, or cost.
- Teacher acts as facilitator. While technology plays a crucial role, teachers remain essential guides. They design learning activities, set goals, and assess progress within

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the immersive environment. They act as co-creators, shaping the virtual world alongside learners.

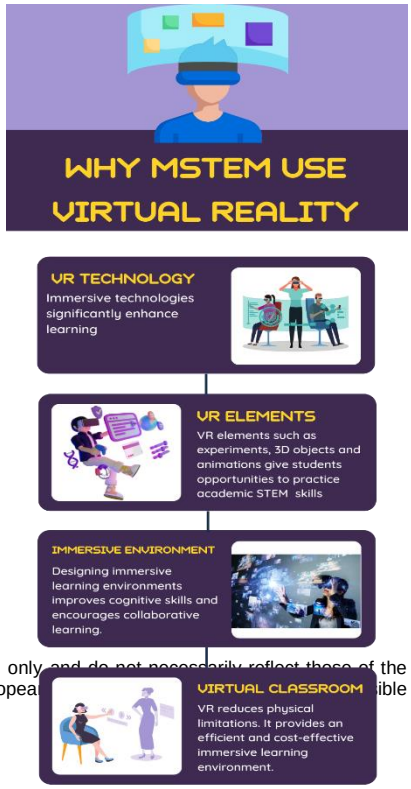
- While teachers provide guidance, learners have control over their learning pace, content selection, and preferred strategies. This fosters self-directed learning and ownership of the process.
- There are different types of immersion: sensory, imaginative, and challenge based. Each type aims to maximize learner enjoyment and engagement, leading to deeper understanding and skill development.

Even in immersive environments, the importance of social learning should not be underestimated. Collaboration and dialogue among learners are crucial for knowledge construction and refinement. Effective integration of technology and course structures is essential for successful immersive learning experiences. It should be noted that in this pedagogy enjoyment is considered a key indicator of learning effectiveness.

In sum, immersive learning offers an intriguing vision that goes beyond traditional models. While emphasizing the potential of technology to create engaging and effective learning experiences, the irreplaceable role of teachers in guiding and facilitating the process should also be recognized.

Why MSTEM use VR?

Although there is a lack of research in this area, users report that immersive technologies significantly enhance learning because these technologies can simplify and simulate complex concepts.



In this project, we aim to exploit the possibilities of virtual reality for teaching STEM subjects. The immersive, interactive and accessible tasks prepared for students provide them with the opportunity to access real experiments, 3D objects and educational animations prepared in a virtual lab, giving them opportunities to practice academic STEM skills in a realistic

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way and creating safe spaces to encourage their full and successful participation in STEM lessons.

Researchers Katie Coleman and Brian Derry from the University of Michigan recently conducted a comprehensive survey aimed at measuring students' reactions to training using VR. The results of this survey showed that more than 75% of respondents indicated that the event had an overwhelmingly positive impact on the participating students. A significant majority of the students emphasized their increased self-confidence as a direct result of the event and stated that the VR platform they used served an effective function for practicing. Many students expressed excitement, describing the activity as interesting and realistic. They praised the clarity of the instructions and emphasized the value of the overall learning experience.

The potential of immersive virtual environments in enhancing learning experiences has been emphasized by many educators. De Back et al. acknowledge the limited adoption of these environments in education but suggest that one reason for this may be the lack of effective design recommendations. Designing immersive learning environments improves cognitive skills and encourages collaborative learning. Utilizing the unique features of the VR platform reduces physical limitations, allowing for the creation of an efficient and cost-effective immersive learning environment for both students and educators.

Theoretical framework

Immersive technologies combine real and virtual worlds, creating experiences that feel artificial but real to users. The use of immersive technologies in education helps students visualize abstract concepts. Immersive technologies also help students develop specialized skills that are more difficult to achieve through traditional education. Researchers have shown that immersive technologies increase engagement and strengthen participation. The use of innovative educational methods based on immersive technologies is very important, especially for today's internet generation students (D. Fonseca et al., 2014).

In today's education, visualization, interaction, personalization, and gamification have become very important elements. The prevailing view is that learning is more effective through practice, through feedback that tells you what was done right and what was wrong, and how to get better. In STEM education, the necessity of thinking and practicing like a scientist in the field is undeniable. Therefore, VR has become a very effective tool. Practical training can be provided

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by creating artificial environments in different fields using VR. For example, anatomy can be explained using medical simulations, while language skills can be improved by establishing interactions with the help of social environments. This practical approach is an ideal solution for STEM education (Salvetti, F., & Bertagni, B., 2017).

Fowler (2015) proposed a pedagogical approach for the use of Virtual Learning Environments in education. Fowler first introduces the stages of learning and explains how they can be represented in learning experiences in virtual learning environments. In the first stage of conceptualization, the learner becomes familiar with the topic and gains a basic understanding. In virtual environments, this is the case, for example, where a particular concept is presented visually and the learner is free to explore and interact with it. The second stage of the structure involves active interaction with the topic, which leads to an advanced understanding. In virtual environments this is associated with higher realism with more possibilities of hands-on interaction with the subject. The third and final stage, dialog, is about discussions with others to confirm and further consolidate understanding. In virtual environments this can be facilitated, for example, through the representation of oneself and others as avatars (Tycho T. De Back et al, 2021).

Fowler lays out a pedagogical "design for learning" approach in which the intended learning outcomes are first identified in order to reach the learning requirements for each of the three learning stages. These learning needs are similar to Dalgarno and Lee's (2010) learning benefits. It is then assessed whether the learning requirements for each phase are adequately supported by the potential learning benefits of virtual learning environments and their underlying characteristics (Tycho T. De Back et al, 2021).

MSTEM pedagogy involves an approach where learning is student-centered and it is based on several learning theories:

1. **Experiential learning - students should work with partners.**

   It is best practice to create a variety of learning experiences for students with different learning styles. Exposing students to a variety of learning experiences will also help them to become more adaptive and well-rounded learners.

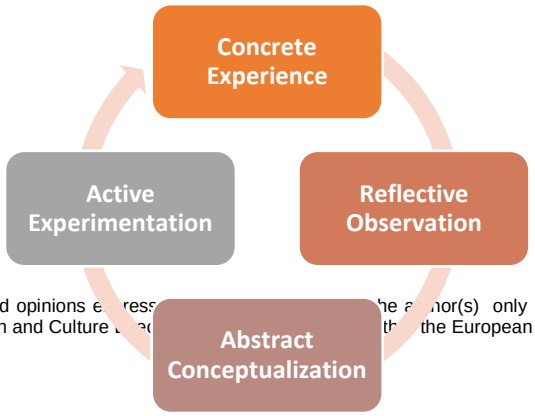

Figure 1 Kolb's Four Stages of Learning

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2. Collaborative learning

In Collaborative learning the activities should include encouraging students to work in groups. In collaborative learning approach, students work together on activities or learning tasks in a group small enough to ensure everyone's participation. Students in the group work together on a common task. In some cases, students may work on separate tasks that contribute to a common outcome. Collaborative learning activities may vary as peer learning, roleplaying and debate. Students may form project groups,

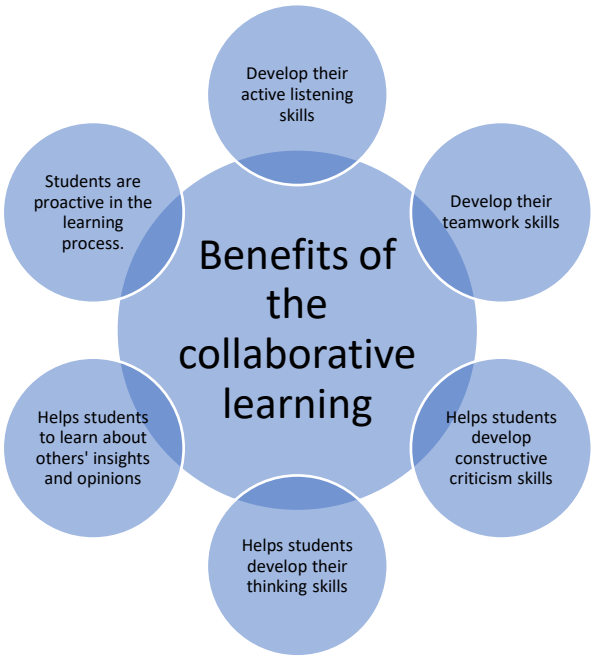

Figure 2 Collaborative learning benefits

discussion groups. writing groups.

3. Constructivist learning - education should be student-oriented.

In constructivist theory, learners do not take in knowledge passively but instead construct it. Learners experience the world and then reflect on these experiences to create their own schema and incorporate new information into their pre-existing knowledge.

A constructivist classroom is characterized by a student-centered approach that values inquiry, hands-on experiences, collaboration and a dynamic understanding of knowledge. Teachers play a facilitative role, guiding students to construct their own understanding through interactive

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processes. Assessment methods reflect a holistic view of learning that emphasizes both the journey and the destination.

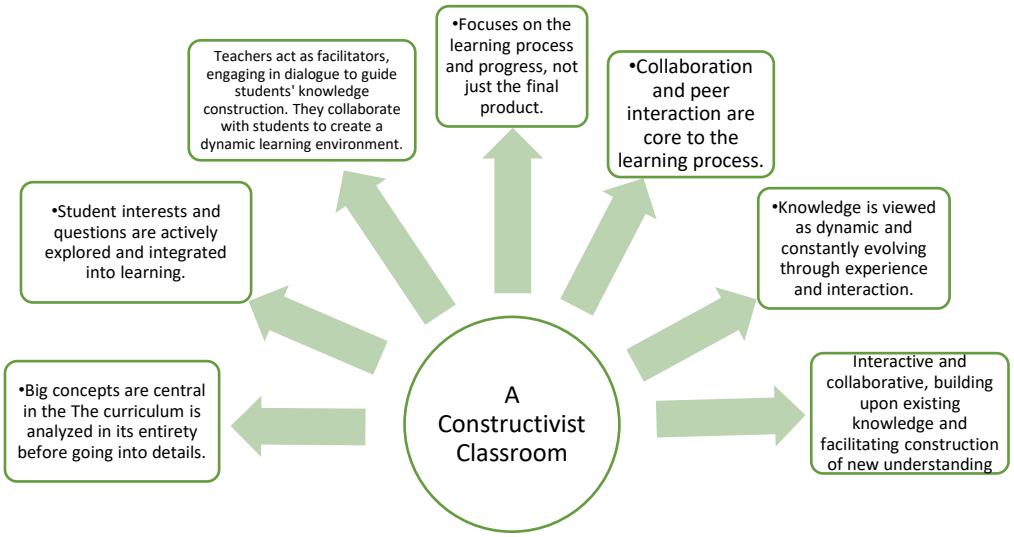

Figure 3 Constructivist Classroom

4. Problem-based learning - Students must solve a problem to learn a subject.

Problem-based learning (PBL) is a student-centered pedagogy in which students learn about a subject through the experience of solving an open-ended problem found in trigger material. The PBL process does not focus on problem solving with a defined solution, but it allows for the development of other desirable skills and attributes. This includes knowledge acquisition, enhanced group collaboration and communication (Wikipedia). In PBL classes students learn about a subject by working in groups to solve the problem.

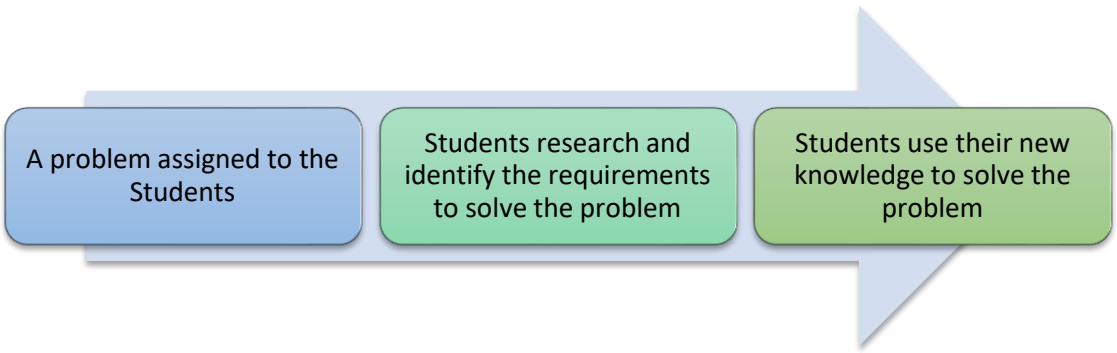

Figure 4 Problem Based Learning Process

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M-STEM pedagogy involves all these aforementioned educational approaches and combines them in a virtual reality environment. The MSTEM platform allows teachers to assign questions to students in a virtual environment. Students can access information about the question using the resources provided on the MSTEM platform. Students can be divided into groups and do group work in the virtual environment. The teacher is involved in the groups as a facilitator and helps students find the solution to the problem. Students learn STEM subjects interactively thanks to the 3D objects, animations and real-time interactions offered on the MSTEM platform.

Interactive applications of a MSTEM course

The integration and use of virtual reality technology enhances student success and learning STEM subjects. MSTEM pedagogy offers a variety of interactive tools to enhance STEM learning; virtual simulations, 3D objects, virtual experiments, collaborative tools and gamification elements designed specifically for teaching STEM subjects (Science, Technology, Engineering, and Mathematics).

Interactive Learning Environment

MSTEM pedagogy involves an interactive learning environment. The virtual learning environment to be designed and developed within the scope of the MSTEM project will serve as a STEM laboratory for students. This Virtual Lab will include various learning tool for students and teachers. 3D objects and animations can be used by STEM teachers to allow students to interact with new materials and experience them immersively, while virtual experiments can be used for interactive learning that allows students to experiment in a safe environment.

Collaborative Tools

The MSTEM virtual lab also features collaborative tools. With the help of these tools, students can conduct an experiment together or discuss STEM topics. These collaborative tools also allow for interactive learning and problem solving through trial and error while exploring realistic 3D objects. The interactive tools offered by the MSTEM platform allow teachers to interact with students during the learning process, which is important for problem-based and student-centered learning.

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MSTEM Lab acts as an activity center for STEM lessons by creating a virtual classroom. On this platform, teachers can create virtual "classes" of specific students and distribute assignments or educational materials to all students in a given class. Students can submit their work through this platform and teachers can access it in real time, present it in the virtual classroom, comment on it and edit it if necessary.

Simulations

In the MSTEM lab, simulations can be used to observe moving objects, such as spinning wheel systems, or to explore natural phenomena that occur over long periods of time, such as the water cycle. It is believed that using simulations in the classroom can help to enhance learning. Simulations are designed to help enhance student STEM learning. Today, simulations are widely used in classroom settings for educational purposes.

Conclusions

MSTEM VR Lab platform offers a realistic STEM lab experience that students and teachers can access to perform experiments in a risk-free environment. The MSTEM VR lab has opportunities and tools that are not available in real labs, such as zooming in to view 3D objects at a micro level and changing time to make experiments faster. Lab simulations can be used for immersive STEM lessons. MSTEM VR also provides a space for creativity and innovation. By changing the laws of physics, students can uncover new processes and lead to brand new discoveries.

Today's students are different from students of the past because of their ability to use technology and therefore have different learning processes and goals. This requires different teaching approaches. VR classrooms, designed with the teacher and students in mind and with attention to the learning content, offer a unique opportunity for teaching STEM subjects. In MSTEM VR pedagogy, teachers have an important role as mediators of digital learning experiences. While the resources available for teachers and students are of high quality, it is critical to evaluate them for curricular relevance, effectiveness, and appropriateness for classroom conditions.BThis Therefore, teachers are an indispensable part of MSTEM pedagogy.

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References:

1. De Back, T. T., Tinga, A. M., & Louwerse, M. M. (2021). Learning in immersed collaborative virtual environments: design and implementation. *Interactive Learning Environments*, 1-19.
2. Meccawy, M. (2022). Creating an immersive xr learning experience: A roadmap for educators. *Electronics*, *11*(21), 3547.
3. Coleman, K., & Derry, B. (2023). Virtual reality in the EAP classroom: Creating immersive, interactive, and accessible experiences for international students. *Language Teaching*, *56*(1), 157-160.
4. Das, A. (2023, May 3). *How To Create Immersive Learning Experiences For Your Learners*. eLearning Industry. https://elearningindustry.com/how-to-create-immersive-learning-experiences-for-your-learners
5. Wagner, C., & Liu, L. (2021). Creating Immersive Learning Experiences: A Pedagogical Design Perspective. *Creative and Collaborative Learning through Immersion: Interdisciplinary and International Perspectives*, 71.
6. Kuhail, M. A., ElSayary, A., Farooq, S., & Alghamdi, A. (2022, September). Exploring immersive learning experiences: A survey. In Informatics (Vol. 9, No. 4, p. 75). MDPI.
7. Fonseca, D., Martí, N., Redondo, E., Navarro, I., & Sánchez, A. (2014). Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models. Computers in human behavior, 31, 434-445.
8. Salvetti, F., & Bertagni, B. (2017). Reimagining STEM Education and Training with e-REAL. 3D and Holographic Visualization, Immersive and Interactive Learning for an Effective Flipped Classroom. *Int. J. Adv. Corp. Learn.*, *10*(2), 63-74.
9. Gardner, M. R., & Elliott, J. B. (2014). The Immersive Education Laboratory: understanding affordances, structuring experiences, and creating constructivist, collaborative processes, in mixed-reality smart environments. *EAI Endorsed Transactions on Future Intelligent Educational Environments*, *1*(1).
10. “Kolb’s Four Stages of Learning - Center for Instructional Technology and Training - University of Florida.” Center for Instructional Technology and Training - University of Florida, https://citt.ufl.edu/resources/the-learning-process/types-of-learners/kolbs-four-stages-of-learning/. Accessed 6 Dec. 2023.

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11. MasterSoft. (n.d.). *What is Collaborative Learning? Benefits & Strategy of Collaborative Learning*. Education ERP Campus Software for Schools & Higher Ed | MasterSoft ERP Solution. Retrieved December 7, 2023, from https://www.iitms.co.in/blog/what-is-collaborative-learning.html
12. Cakir, M. (2008). Constructivist approaches to learning in science and their implications for science pedagogy: A literature review. International journal of environmental and science education, 3(4), 193-206.
13. Constructivism - Office of Curriculum, Assessment and Teaching Transformation - University at Buffalo. (2023, April 4). https://www.buffalo.edu/catt/develop/theory/constructivism.html#:~:text=Constructivism%20is%20the%20theory%20that,%2Dexisting%20knowledge%20(schemas).
14.

Useful Links:

1. For a better insight on Collaborative Learning: https://www.structural-learning.com/post/collaborative-learning

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