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Editorial

Immersive technologies in science, technology and mathematics education: Enhancing experiential learning and real-world applications

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This special issue originated from discussions on emerging directions in STEM education, particularly the growing interest in extending learning beyond conventional classroom settings through the use of immersive technologies. Through a series of consultations and refinements with the Editor-in-Chief, the initial broad theme was narrowed to focus on a more specific and timely area that aligns with the scope and mission of LUMAT. The resulting theme centers on the application of immersive technologies, particularly Virtual Reality (VR) and Augmented Reality (AR), within STEM learning environments. Emphasis is placed on studies that examine how these technologies facilitate experiential learning and support real-world applications, both in educational settings and in contexts that prepare learners for professional practice. This special issue therefore seeks to showcase evidence-based research that demonstrates the pedagogical value, implementation, and impact of immersive technologies in contemporary STEM education.

The special issue, “Immersive technologies in science, technology and mathematics education: Enhancing experiential learning and real-world applications,” explores the transformative role of immersive technologies, including VR, AR, and interactive simulations, in advancing STEM education. Grounded in the principles of experiential learning, which emphasize knowledge construction through active engagement, experience, and reflection (Kolb, 1984), these technologies provide learners with opportunities to interact with authentic and simulated environments that extend beyond the limitations of traditional classroom instruction. Immersive learning environments have been consistently reported to enhance learner engagement, conceptual understanding, collaboration, and problem-solving by connecting abstract concepts to realistic contexts (Merchant et al., 2014; Radianti et al., 2020). As educational institutions increasingly seek innovative approaches to prepare learners for complex real-world challenges, immersive technologies offer promising avenues for bridging theoretical knowledge with practical application. In this regard, the special issue highlights research that examines the design, implementation, effectiveness, and impact of immersive technologies in STEM education. The following sub-themes reflect the interconnected areas represented in this issue:

- *Integration of Immersive Technologies in Science and Mathematics Education*
  Explores the use of Virtual Reality (VR), Augmented Reality (AR), and interactive simulations to enhance the teaching and learning of complex scientific and mathematical concepts.

- *Experiential Learning and Problem-Based Learning (PBL) with Immersive Tools*
  Examines how immersive technologies support experiential and problem-based learning through authentic scenarios and real-world problem-solving.

- *Interdisciplinary Approaches to Immersive Education*
  Focuses on the application of immersive technologies across disciplines, including environmental science, sustainable development, agricultural education, and the physical sciences.

- *Immersive Tools for Collaborative Learning and Feedback Integration*
  Investigates the role of immersive technologies in facilitating collaboration, peer interaction, and feedback processes to enhance learning experiences.

- *Assessing the Impact of Immersive Technologies on Education*
  Evaluates the effects of immersive technologies on learner engagement, academic performance, skill development, and other educational outcomes.

Among the manuscripts submitted to this special issue, two papers were published, while several progressed to the external review stage but was ultimately not accepted. Total number of submissions was 46 resulting an acceptance rate of 4%. This outcome reflects the rigorous editorial and peer-review standards maintained by LUMAT editors and guest editors, as well as the highly focused scope of the special issue. Particular emphasis was placed on studies that explicitly addressed the use of immersive technologies, particularly VR and AR, to facilitate experiential learning and real-world applications through interactive learning environments that extend beyond conventional online and distance-learning approaches. While several submissions demonstrated relevance to STEM education, some did not sufficiently align with the central theme, whereas others required substantial improvements in research design, scholarly rigor, and manuscript quality to meet the standards expected of LUMAT.

The first manuscript published, titled "Exploring students' scientific reasoning during virtual game in STEAM problem solving" was authored by López Takegami and colleagues and investigated the development of scientific reasoning among 53 tenth-grade students engaged in a VR/AR-supported STEAM problem-solving activity using an interactive simulation. Employing a microgenetic approach across eight sessions, the findings revealed a progressive shift from descriptive to more causal and mechanistic reasoning. The study highlights the pedagogical value of VR/AR-based immersive tools in fostering experiential learning and strengthening higher-order scientific reasoning, aligning closely with the aims of this special issue.

Finally, the second manuscript, titled "Augmented reality simulations in science education for questioning and explaining geoscience phenomena" was authored by Cabello and colleagues and investigated how AR supports 69 fourth-grade primary students' understanding of geoscientific phenomena, focusing on teacher–student interactions during AR-enhanced lessons on earthquakes, volcanoes, and Earth's structure. Findings showed that AR was most effective for conceptual learning when teachers moved beyond procedural guidance and employed dialogic, metacognitive questions that encouraged explanation and reflection, thereby highlighting the pedagogical value of AR.

We hope this special issue will encourage further research into immersive technologies, particularly VR and AR, and inspires further high-quality investigations and publications on their role in supporting experiential learning and real-world applications across STEM education and related fields.

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