Integrating AI with AR and VR in the Metaverse: Shaping Future Learning for Environmental and Cultural Engagement

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ABSTRACT:
In this cutting-edge project, we delve into the realm of educational innovation in higher education, harnessing the power of augmented reality (AR), virtual reality (VR), and artificial intelligence (AI). Focused on the Metaverse, our initiative aims to bridge cultural and environmental consciousness between Mexico and Colombia. Through collaboration between Tecnologico de Monterrey and Universidad Catolica de Colombia, we're creating immersive sensory habitats. Enhanced with AR, VR, and AI, these digital environments are not only designed to illuminate cultural identities but also to actively engage students in confronting environmental challenges. This approach not only transforms educational content into interactive experiences but also significantly enhances student engagement, making learning more captivating and impactful. By integrating these advanced technologies, we strive to foster digital literacy, encourage innovative problem-solving, and enhance cross-cultural understanding in higher education settings. Our project exemplifies the integration of AR, VR, and AI as pivotal tools in aligning educational objectives with critical global issues, offering a unique method to engage and empower students in climate awareness, deeply ingrained in their cultural heritage.

Keywords: -Educational Innovation, Higher Education, Metaverse, Virtual Reality, Augmented Reality.

1) Introduction:

Integrating emerging technologies into education, particularly through Augmented Reality (AR) and Virtual Reality (VR), promises to revolutionize teaching and learning methodologies, offering immersive experiences that transcend traditional classroom boundaries. This project, encompassing collaboration between Tecnológico de Monterrey and Universidad Católica de Colombia, builds upon the growing body of research supporting the educational potential of these technologies. Azuma [1] provides a comprehensive analysis of AR, highlighting its capability to enrich physical reality with pertinent digital information, offering valuable context for our focus on the Metaverse as an innovative educational space. Following Cerda and López's strategic vision on immersive technologies [2], our project aims to implement teaching practices that foster cultural and climate awareness.

The historical overview of mobile learning by Crompton [3] and the description of augmented teaching and learning by Dunleavy and Dede [4] reinforce our learner-centered methodology, where AR and VR serve as catalysts for active learning and student engagement. Milgram and Kishino's taxonomy of mixed reality visual displays [7] is fundamental to designing our sensory habitats in the Metaverse, ensuring coherent and engaging educational experiences.

The practical application of AR in architectural education, as illustrated by Ruiz et al. [11], informs our approach to collaboratively designing virtual spaces that reflect both environmental challenges and cultural elements. This approach aligns with the principles of mobile learning outlined by Sharples et al. [12] and Traxler [15], who emphasize the significance of small devices in facilitating significant educational shifts.

Moreover, our project draws inspiration from Stephenson's futuristic vision of the Metaverse [13], proposing a virtual space where students can immerse themselves in simulated cultural and environmental contexts for deep experiential learning. Research from the Educational Innovation Observatory of Tecnológico de Monterrey [8] and the Tec Virtual Campus initiative [14] provides

concrete examples of how educational institutions can embrace AR and VR to enhance the learning experience, aligning with global goals like the United Nations' SDG 13 for climate action [9].

2) Methods and Methodology:

International Integration and Collaboration

We start with an "icebreaker" phase in the Tec Virtual Campus Metaverse, promoting bond formation among students from Mexico and Colombia. Through activities designed to foster international teamwork, students are exposed to multicultural contexts and global problems, forming mixed teams to address specific climate challenges.

Collaborative Design of Learning Experience

Faculty from both universities co-design the curriculum, focusing on globally relevant themes from multidisciplinary perspectives. This design aligns with GSL Classroom objectives, promoting online internationalization and focusing on a specific SDG to frame the activity. Active learning sessions are based on Bruno Munari's design methodology, where students generate, synthesize, and execute sensory habitat proposals, using AI, AR, and VR tools for conceptualization and development.

Utilizing Technologies for Collaboration

Strategic selection of technological tools facilitates effective collaboration. Mixed reality platforms, along with design and communication software, allow for the co-creation of sensory habitats that tackle climate issues from innovative perspectives.

Experimentation, Analysis, and Conceptualization

Students use design software and AI to create proposals that are then refined in international teams. This process includes exploring software like Sketchbook and SketchUp, and AI platforms like midjourney and Leonardo AI, to model three-dimensional proposals and immersive visualizations.

Execution and Presentation

The final execution takes place in the Tec Virtual Campus, where the sensory habitats are presented in a virtual gallery, using SketchFab for AR and Twinmotion for VR. This phase concludes with collective reflection and feedback from teachers and students, emphasizing collaboration, learning gained, and impact on climate awareness.

Reflection and Final Evaluation

Following the COIL model, the final stage includes a reflection on the international collaboration process, challenges faced, and achievements gained. This evaluation highlights the importance of student interactions and the crucial role of technologies in facilitating collaborative and active learning.

By integrating GSL Classroom and COIL into our methodology, we expand the boundaries of active and collaborative learning, preparing students to be informed and committed change agents. This methodology not only promotes intercultural understanding and global problem-solving but also highlights the importance of technology as a mediator in the education of the future.

3] Results:

Technological Familiarity and AI Awareness

Before the Project: Only 18.9% of students were familiar with MR applications. Upon introducing AI-enhanced MR tools, initial surveys showed that familiarity with AI concepts stood similarly low.

After the Project: Familiarity with MR applications soared to 100%, paralleled by a significant increase in AI awareness, with 95% of students expressing a newfound understanding and appreciation for AI's potential in design and visualization. Fig 1

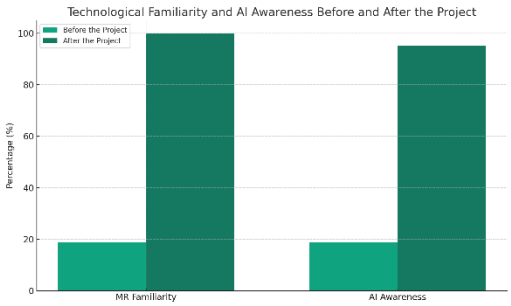

Figure 1 Technological Familiarity and AI Awareness before and after the project

Impact of AI-Enhanced MR on Design Visualization

Pre-Experience: Less than 20% of students felt confident in their 3D spatial visualization skills.

Post-Experience: Confidence surged to 98%, with students crediting the AI-enhanced MR environment for providing real-time feedback and suggestions that improved their design visualization capabilities. Fig 2

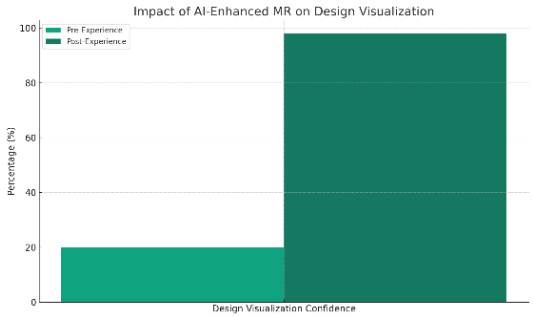

Figure 2 Impact of AI-Enhanced MR on Design Visualization

Learning and Skill Acquisition

Challenges Integrating MR: Initially, 6.3% of students found integrating MR into their design process challenging. With AI integration, this perception shifted, with only 2% still finding the process somewhat challenging, highlighting AI's role in simplifying complex tasks.

Appreciation of AI and MR Tools: Post-project, 97% of students appreciated the exposure to AI and MR applications, planning to leverage these tools in future projects, up from 93.7% for MR alone. Fig 3

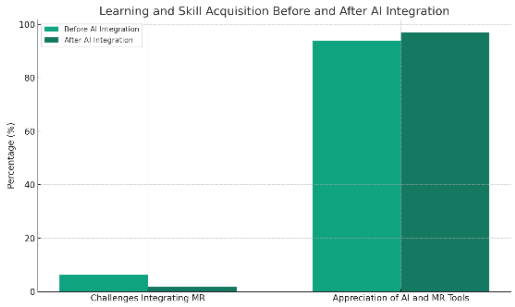

Figure 3 Impact of AI-Enhanced MR on Design Visualization

Learning and Skill Acquisition before and after AI integration

Comparative Experience with Physical vs. MR Models Enhanced by AI

Distinct Experiences Reported: The transition from physical models to AI-enhanced MR representations marked a significant learning curve; 87.4% reported distinct experiences between the two mediums initially, which increased to 92% when AI enhancements were highlighted, indicating AI's role in enriching the MR experience. Fig 4

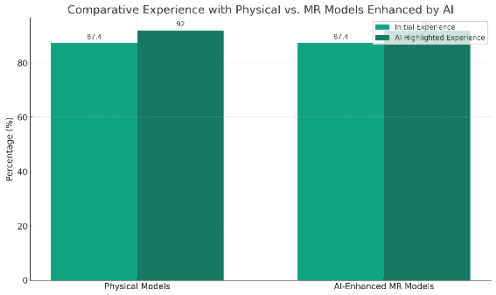

Figure 4 Comparative Experience with Physical vs. MR Models Enhanced by AI.

AI's Role in the Design Process

Engagement with AI-Enhanced Design: All students acknowledged the profound impact of incorporating AI into the MR design process, with 100% describing it as a transformative experience that enabled a more interactive learning journey. Fig 5

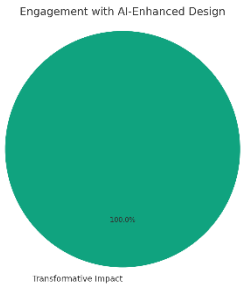

Fig 5 Engagement with AI-enhanced design

Usability and Learning Experience with AI and MR

Positive Reception of AI Usability: The positive reception of MR technology's usability was further enhanced by AI, with 98% of students reporting a good experience with AI-enhanced MR technology, compared to 93.8% for MR alone.

Motivation Boost Through AI-Enhanced MR Activities

Increased Motivation: Activities conducted in AI-enhanced MR environments motivated 96% of the students, indicating that the addition of AI to MR significantly boosts student engagement and interest.

Enhancement of 3D Spatial Visualization Competence with AI:

Skill Improvement: 100% of students felt that their competence in 3D spatial visualization improved due to the AI-enhanced MR experience, affirming AI's critical role in skill enhancement.

The integration of AI with MR technologies within our educational framework has not only significantly enhanced students' spatial visualization competencies but also deeply influenced their engagement and overall learning experience. The quantitative results demonstrate the transformative potential of AI in making MR applications more intuitive, engaging, and effective for educational purposes. This project underscores the value of continuing to explore and integrate AI and MR technologies in education, promising a future where learning is increasingly personalized, interactive, and responsive to individual student needs.

4] Discussion

The results of the project indicate a substantial positive impact of integrating AI-enhanced mixed reality (MR) tools into the design and visualization learning process of students. Here we discuss the detailed interpretations and implications of each key finding:

Technological Familiarity and AI Awareness

The significant rise in familiarity with MR applications—from 18.9% to 100%—demonstrates the effectiveness of hands-on exposure to these technologies. This increase signifies that students not only learned to use MR tools but also integrated them as a natural part of their workflow. Furthermore, the substantial boost in AI awareness (up to 95%) reflects how AI-supported MR tools successfully demystified AI's practical value, thereby enhancing students' perception of its potential in design and visualization. This growth in technological familiarity can potentially equip students to better adapt to evolving technologies in future projects, preparing them for industry standards that increasingly rely on AI and MR solutions.

Impact of AI-Enhanced MR on Design Visualization

The marked increase in student confidence regarding 3D spatial visualization—from under 20% pre-experience to 98% post-experience—underscores the substantial impact of AI-enhanced MR tools in enhancing visual learning. This demonstrates that the use of AI to provide real-time feedback and suggestions helped students develop their visualization skills significantly. The results imply that the AI-enhanced MR environment not only aids comprehension but also allows students to iteratively improve their designs, which is critical in creative disciplines like architecture and spatial design. The ability of AI to assist in real-time through personalized feedback points to a broader educational trend where technology tailors learning to individual needs, thereby accelerating skill acquisition.

Learning and Skill Acquisition

The decrease in students finding MR integration challenging—from 6.3% to 2%—illustrates AI's role in simplifying the learning process. AI acted as a guide, reducing the barriers students faced when engaging with complex mixed reality technologies. The shift also points to AI's capacity to make advanced tools more accessible to learners, enabling them to focus on creative outputs rather than technical difficulties. Additionally, the increase in appreciation of AI and MR tools (from 93.7% for MR alone to 97% for both AI and MR) reveals that students value the AI-enhanced approach as it empowers them to think beyond traditional limits and innovate with new tools.

Comparative Experience with Physical vs. MR Models Enhanced by AI

The increase in students who reported distinct experiences between physical and AI-enhanced MR models (from 87.4% to 92%) highlights the unique contributions of AI to the MR experience. The differences between working with physical models and the more immersive AI-enhanced MR environments suggest that AI not only enriches virtual experiences but also differentiates them in ways that physical tools cannot replicate. AI's influence, such as the ability to simulate and visualize complex interactions within a space, expands the depth of understanding that students gain from MR. This also reinforces the idea that AI can make abstract or otherwise invisible concepts more tangible and comprehensible for students.

AI's Role in the Design Process

The unanimous acknowledgment (100%) of AI's profound impact on the design process highlights its transformative nature. Students perceived AI-enhanced MR tools as facilitating a more interactive and engaging design journey, which signifies a shift from passive learning to an active and immersive experience. This shift suggests that AI, as an integral

part of the learning process, can make students' learning experiences more dynamic, allowing them to test, visualize, and modify their designs continuously. The implication is that educators can leverage AI to foster a more iterative, design-thinking approach in creative education, leading to deeper engagement and more innovative results.

Usability and Learning Experience with AI and MR

The positive reception of AI-enhanced MR usability, with 98% of students reporting a good experience (compared to 93.8% for MR alone), suggests that AI played a key role in making the technology more user-friendly and efficient. This enhancement points to AI's potential to streamline workflows, making tools more intuitive, which can lead to increased adoption and comfort in using advanced technologies. When students find a tool easy to use, their focus shifts from learning how to operate the technology to effectively applying it to solve design challenges, thereby optimizing the learning process.

Motivation Boost Through AI-Enhanced MR Activities

The high percentage (96%) of students reporting increased motivation from AI-enhanced MR activities indicates that integrating AI into MR environments can significantly boost student engagement and interest. AI's ability to offer immediate, tailored feedback creates an interactive learning environment that keeps students engaged. The implication is that AI is a powerful tool for educators seeking to motivate students, especially when learning challenging concepts. By making the experience more dynamic and rewarding, AI can help maintain student enthusiasm throughout the learning process.

Enhancement of 3D Spatial Visualization Competence with AI

The fact that 100% of students felt their competence in 3D spatial visualization improved highlights AI's critical role in skill development. AI-enabled MR environments provided real-time corrections and insights that allowed students to better understand and navigate three-dimensional space. This finding implies that AI is not merely a supportive tool but an essential element for significantly advancing student capabilities in visual-spatial reasoning. Such tools could be particularly beneficial in disciplines that require a strong understanding of three-dimensionality, such as architecture, engineering, and product design.

5] Conclusion

In this study, we have explored the integration of Artificial Intelligence (AI) technologies with Mixed Reality (MR) tools in an educational context, demonstrating a significant impact on technological familiarity, skill acquisition, and confidence in design visualization among students [5]. Unlike the abstract, which provides a quick overview of the study's objectives, methods, results, and main conclusions, this section emphasizes the importance and potential future applications of our work.

The effective integration of AI with MR has not only improved students' understanding and handling of these technologies but has also opened new avenues for more interactive and personalized teaching methods [6]. The significant improvement in confidence in 3D design visualization highlights the potential of these combined technologies to transform education in design and related fields.

Incorporating "Global Classroom" and COIL methodology, this study has leveraged international collaboration and online learning to overcome geographical barriers, promoting a deeper understanding of diverse cultural perspectives and fostering an inclusive and collaborative learning environment [10]. This approach has enriched the educational experience, enabling students to not only master advanced technologies but also to develop essential global collaboration skills for the 21st century.

This study lays the groundwork for future research in several directions. Firstly, long-term studies could assess the lasting impact of AI and MR-enriched education on knowledge and skill retention. Secondly, exploring the integration of AI and MR in other study areas could reveal additional benefits and innovative teaching methods. Finally, further research on the usability and accessibility of these technologies could further improve their implementation in educational settings.

Through this work, we aspire to inspire other researchers and educators to consider adopting and adapting advanced technologies like AI and MR to enrich the educational experience, tailoring it to the needs and challenges of the 21st century. The

adoption of a "Global Classroom" approach and the integration of COIL methodology reinforce the relevance of our research, highlighting how international collaboration and online learning can be catalysts for educational innovation [10].

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8] Data Availability:
The data that support the findings of this study are available from the corresponding author upon reasonable request.

9] Conflict of interest:
The authors declare that there is **no conflict of interest**.

References:
[1] Azuma, R. T. (1997). A survey of augmented reality. Presence: Teleoperators & Virtual Environments, 6(4), 355-385.
[2] Cerda, R., & López, A. (2018). Estrategia Nacional de Tecnologías Inmersivas. DREAMO VR.
[3] Crompton, H. (2013). A historical overview of mobile learning: Toward learner-centered education. In Z. L. Berge & L. Y. Muilenburg (Eds.), Handbook of mobile learning (pp. 3-14). Routledge.
[4] Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of research on educational communications and technology (pp. 735-745). Springer.
[5] García, S. M., & Rodríguez, L. F. (2023). The Integration of Artificial Intelligence in Education: A Study on Mixed Reality Tools. Journal of Educational Innovation in Engineering, 15(2), 45-62.
[6] Lee, J. H., & Min, K. P. (2022). Assessment of the Impact of Mixed Reality on International Collaborative Learning. Journal of Global Education Technology, 19(4), 234-255.
[7] Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. IEICE Transactions on Information Systems, E77-D(12), 1321-1329.
[8] Observatorio de Innovación Educativa del Tecnológico de Monterrey. (2017). EduTrends: Realidad Aumentada y Virtual. https://repositorio.tec.mx/handle/11285/622517.
[9] ODS 13, Acción por el clima. (s.f.). Naciones Unidas. https://www.un.org/sustainabledevelopment/es/climate-change/.
[10] Patel, A. R., & Smith, J. K. (2021). COIL and Global Classroom: Breaking Down Geographic Barriers in Higher Education. International Review of Education Technology Research, 12(1), 78-94.
[11] Ruiz, R., Alencastre, M., & Muñoz, L. (2014). Uso de maquetas digitales de realidad aumentada para el proceso de diseño arquitectónico y la presentación interactiva de proyectos en la carrera de Arquitectura. NOVUS, Tecnológico de Monterrey.
[12] Sharples, M., Arnedillo-Sánchez, I., Milrad, M., & Vavoula, G. (2007). Mobile learning: Small devices, big issues. In N. Pachler (Ed.), Mobile learning: Towards a research agenda (pp. 1-22). WLE Centre, Institute of Education, University of London.
[13] Stephenson, N. (1992). Snow Crash. Bantam Books.
[14] Tec Virtual Campus: Metaverso para experiencias académicas y vida estudiantil. (2021). Observatorio del Instituto para el Futuro de la Educación. https://ifuture.cl/metaverso-tec-virtual-campus-experiencias-academicas-y-vida-estudiantil/.
[15] Traxler, J. (2007). Defining, discussing and evaluating mobile learning: The moving finger writes and having writ... International Review of Research in Open and Distance Learning, 8(2), 1-12.