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Innovating Higher Education: Integration of AI, Mixed Realities, and the Metaverse Through Global Collaboration

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Abstract

The present project, developed in collaboration between Tecnologico de Monterrey, Universidad de San Sebastián in Chile, and Universidad Católica de Colombia, introduces an advanced methodology for integrating emerging technologies in higher education. This methodology combines artificial intelligence, mixed realities, the Metaverse, and the Global Classroom program to enhance the teaching of the course "Formal Representation of Space." The results show significant improvements in three-dimensional spatial visualization and student engagement, supported by pretest and post-test data.

Keywords: Educational innovation, Higher education, Mixed realities, Artificial intelligence, Metaverse.

Introduction

The integration of emerging technologies in higher education, such as artificial intelligence (AI), mixed realities, and the Metaverse, is revolutionizing the way students learn and prepare to face the challenges of an increasingly globalized and technologically advanced world. These tools not only enhance students' technical and creative skills but also facilitate international collaboration and intercultural understanding, which are crucial aspects in the training of professionals in any discipline (Bower, 2017; De Wit, 2019).

This project focuses on implementing an innovative methodology in the course "Formal Representation of Space," combining AI, mixed realities, and the Metaverse within the Tec Virtual Campus. Through this methodology, students not only develop technical skills in three-dimensional spatial visualization but also collaborate with peers from different disciplines and cultures, fostering comprehensive learning and a global perspective (Garrison, Anderson, & Archer, 2000; Rubin, 2020).

In light of the above, this research aims to systematize the experiences of students from various disciplines such as Architecture, Design, Digital Art, Communication, and Music Production in using emerging technologies and their impact on spatial visualization and international collaboration. Students from universities in Mexico, Chile, and Colombia worked together in the design and validation of projects incorporating AI, mixed realities, and the Metaverse, aiming not only to improve their technical competencies but also to develop intercultural and collaborative skills in a globalized environment (Hajirasouli & Banihashemi, 2022; Lee et al., 2024).

Theoretical Framework

Recent research suggests that the use of generative technologies can significantly improve teaching and learning by personalizing the educational experience and facilitating more active student participation (Lee et al., 2024). These technologies allow for the creation of a more interactive learning environment tailored to individual needs, which is crucial for enhancing pedagogical effectiveness in higher education.

Mixed realities, which combine augmented reality (AR) and virtual reality (VR), are crucial in fields such as architecture and construction, as they improve spatial visualization skills and the understanding of complex concepts through interactive environments. According to Hajirasouli and Banihashemi (2022), these technologies not only enrich interaction with academic content but also allow students to manipulate and explore design elements in a context that simulates real situations, which is fundamental for their professional training. The ability to experiment and adjust designs in real-time facilitates deeper and more applied learning, aligning with the demands of the current job market.

The Metaverse within the Tec Virtual Campus plays a key role in our methodology, facilitating real-time interaction and collaboration among students from different geographies while also offering a space for creative experimentation and exploration. This teaching strategy is based on the Community of Inquiry theory (Garrison, Anderson, & Archer, 2000), which emphasizes the importance of social, cognitive, and teaching presences in online learning environments. The principles of the collaborative-constructivist paradigm (Scardamalia & Bereiter, 2006) also inform our practice, viewing students as active co-creators of their learning, promoting a more participatory and constructive approach to education.

Central to this initiative is the incorporation of the Collaborative Online International Learning (COIL) methodology, developed by Jon Rubin at the State University of New York (SUNY). COIL is instrumental in linking courses at Tecnológico de Monterrey with those of international universities, fostering a global classroom environment. This methodology promotes the development of intercultural communication skills, critical thinking, and global citizenship, thereby enhancing the multicultural collaborative learning experience (Rubin, 2020).

The COIL methodology has been growing for over a decade, but the global pandemic period revealed its true potential and the interesting opportunities it provides through the mediation of technological tools in a digital environment that became familiar to all participants. This digital context has allowed the participants from different institutions to commit to consolidating the internationalization of the curriculum with new disciplinary perspectives, implementing new methodologies, enhancing or updating content, and creating new and improved guides and resources for the courses.

The most important value that can be acquired through virtual education processes is the elimination of distance and time limitations, and the acquisition of competencies that allow all participants to experience meaningful skills in a globalized world, while achieving cultural enrichment and competitive learning mediated by technologies (De Wit, 2019).

To evaluate the effectiveness of the educational process, validated measurement instruments are employed that capture crucial data on spatial three-dimensionality and student engagement. Pre-test and post-test surveys are fundamental in this approach, as they provide a clear view of the impact these technologies have on the development of technical and creative competencies, as well as in promoting deep intercultural understanding and significant engagement among students (Garrison et al., 2000).

Moreover, the responses and testimonials from students who have participated in this innovative educational program underscore the effectiveness and transformative reach of our methodology. The students have expressed notable growth in their technical and creative skills, as well as a deepened appreciation for intercultural and interdisciplinary collaboration. These comments reflect a clear recognition of the relevance and practical application of the taught technologies and strategies, demonstrating that students not only absorb technical knowledge but also feel empowered to apply these learnings in meaningful and real-world contexts.

The achievements reached are reflected in the participants' results in areas of interdisciplinary work, promotion of competencies in design, production, and architecture, as well as in the increase in motivation and confidence in developing creative skills. Additionally, the importance of the cultural characteristics of their academic peers is recognized, which facilitates effective communication among new generations, opening up a broader spectrum of global competencies. For teachers, academics, and administrators, this approach allows for a deep understanding of the cultural needs and language of new generations, resulting in a meaningful experience for their academic and personal development.

Method

The methodology of this research is of a mixed nature, with a cross-sectional and descriptive approach. The study was developed in two main phases, focused on the implementation of emerging technologies in higher education and the evaluation of the impact of these technologies on student learning and engagement.

First Phase: Implementation of the Methodology

In the first phase, various emerging technologies were integrated into the course "Formal Representation of Space." These technologies include artificial intelligence (AI), mixed realities (augmented reality and virtual reality), and the use of the Metaverse, specifically through the Tec Virtual Campus. The following details how each technology was implemented:

Artificial Intelligence (AI) with Leonardo AI:

Implementation: Students used Leonardo AI to generate prompts and design concepts based on their initial sketches and physical models. This AI tool provided creative and technical suggestions that students integrated into their design projects, allowing for continuous iteration and optimization of the creative process. This generative AI was used from the ideation phase to the design refinement phase.

Augmented Reality (AR) with SketchFab:

Implementation: In the early weeks of the course, students used iPads with the SketchFab application to visualize their three-dimensional designs in an augmented reality environment. This technology allowed them to digitally overlay their models in real environments, facilitating an immediate understanding of scale, proportion, and design integration in specific contexts. Students could adjust and refine their designs in real-time, observing how they would appear in real-world scenarios.

Virtual Reality (VR) with Oculus and Twinmotion:

Implementation: During the advanced stages of the project, students used Oculus headsets with the Twinmotion platform to explore their designs in a fully immersive virtual reality environment. This technology allowed students to "walk" through their projects, experiencing spaces as if they were already constructed. VR was crucial for evaluating and adjusting design elements in terms of functionality, aesthetics, and sensory experience. Students used this tool to make virtual presentations to their peers and professors, receiving real-time feedback.

Metaverse with Tec Virtual Campus:

Implementation: The Tec Virtual Campus Metaverse served as a platform for collaborative work sessions and presentations between students from Mexico, Chile, and Colombia. This immersive digital environment facilitated real-time interaction and international collaboration. Students used the Metaverse to share progress, discuss ideas, and receive feedback from both peers and professors. Additionally, final project presentations were conducted within this environment, providing a more dynamic and global educational experience.

The combination of these technologies enabled students not only to improve their technical skills in spatial visualization and design but also to develop intercultural collaboration and effective communication skills in a globalized environment.

Second Phase: Impact Evaluation

The second phase of the methodology focused on evaluating the impact of integrating these emerging technologies on student learning. The following evaluation strategies were employed:

Pre-Test and Post-Test Surveys:

Implementation: Surveys were administered at the beginning and end of the course to measure the development of technical skills, spatial three-dimensionality, and student engagement. The surveys included specific questions about students' perceptions of the use of each technology and its impact on their learning process.

Focus Groups and Interviews:

Implementation: Focus groups and individual interviews were conducted with students and professors to explore in-depth their experiences and perceptions of the use of the technologies. These sessions provided valuable qualitative information that complemented the quantitative data obtained from the surveys.

Data Analysis:

Implementation: A mixed approach was used in data analysis, combining measures of central tendency and dispersion to assess the impact on technical and creative competencies, as well as student engagement. The qualitative analysis of the interviews and focus groups allowed for the identification of emerging themes related to intercultural collaboration and the use of technologies in education.

The methodological design, which combines advanced technology with robust evaluation strategies, ensures that the results obtained accurately reflect the impact of these innovations in higher education.

Results

The course "Formal Representation of Space" was conducted over 5 weeks during an academic period, involving 54 students distributed across 3 sections. These students came from various disciplines, such as Architecture, Design, Digital Art, Communication, and Music Production.

Table 1 summarizes the distribution of students by section

Section	Architecture	Design	Digital Art	Communication	Music Production	Total
1	10 (19%)	12 (22%)	8 (15%)	8 (15%)	10 (19%)	48
2	15 (28%)	10 (19%)	9 (17%)	5 (9%)	15 (28%)	54
3	20 (37%)	8 (15%)	10 (19%)	6 (11%)	10 (19%)	54

During the course, students were organized into subgroups of 10 to 12 members to work on collaborative projects that integrated emerging technologies such as artificial intelligence (AI), augmented reality (AR), virtual reality (VR), and the Metaverse. Table 2 shows the distribution of these subgroups and their main activities.

Table 2. Distribution of student subgroups and main activities

Subgroups	Main Activities
1	Design and visualization of spaces using AR and VR.
2	Generation of creative concepts using AI for architectural design projects.
3	International collaboration in the Metaverse for project presentation and validation.
4	Evaluation and adjustment of designs in interactive virtual environments.
5	Implementación de metodologías COIL para promover la colaboración intercultural.

The course was developed over 5 weeks, with synchronous and asynchronous sessions and activities in the Metaverse. During synchronous sessions, conceptual content was presented, and learning strategies such as lectures, case analysis, and group tutoring were utilized. In the Metaverse, students participated in real-time presentations and collaborations with students from universities in Chile and Colombia.

Course evaluations focused on the students' ability to apply emerging technologies in architectural design, as well as their ability to work in interdisciplinary and international teams. Evaluation activities included questionnaires, project logs, presentations in the Metaverse, and peer evaluations.

Table 3. Presents the main activities carried out in the course.

Sessions	Course Actions
1	Introduction and use of AI for generating design ideas.
2	Visualization of projects in AR and VR for design adjustment and validation.
3	International collaboration in the Metaverse and real-time feedback.
4 and 5	Final project presentation and collaborative evaluation.

The course content, distributed across conceptual, procedural, and attitudinal dimensions, is summarized in Table 4.

Table 4. Conceptual, procedural, and attitudinal content of the course

Conceptual	Procedural	Attitudinal
Fundamentals of architectural design	Techniques of threedimensional visualization	Interdisciplinary teamwork
Community of Inquiry Theory	Use of AI for idea generation	Intercultural collaboration
COIL Methodology	Application of AR and VR in design	Adaptability and collaborative learning
Innovation in the use of the Metaverse	Project presentation and validation	Ethics and responsibility in global collaboration

The course evaluation included a combination of questionnaires, performance assessments, and peer feedback to measure both the mastery of technical content and the students' generic competencies. Table 5 summarizes the main grades obtained by the students in the course.

Table 5. Main grades obtained in the course

Evaluation	Average Grade (1.0 - 7.0)	Standard Deviation
Knowledge Assessment	6.2	0.5
Project Log	6.4	0.6
Presentations in the Metaverse	6.5	0.5
Peer Evaluation	6.3	0.7

Discussion

The results obtained in this study clearly demonstrate the effectiveness of integrating emerging technologies such as artificial intelligence (AI), augmented reality (AR), virtual reality (VR), and the Metaverse into the teaching of the course "Formal Representation of Space." These technologies not only significantly improved the students' threedimensional visualization abilities and engagement but also promoted effective collaboration among students from different disciplines and countries.

Expansion to Other Educational Contexts

The technologies implemented in this course can be applied in various disciplines beyond architecture and design:

- Health Sciences: The use of VR to simulate clinical scenarios and surgical procedures could enhance practical training for students.
- Primary and Secondary Education: AR can transform the teaching of natural sciences and mathematics by providing immersive and visually enriching learning experiences.
- Engineering: AI could personalize learning processes in areas such as physics and mathematics, tailoring content to each student's needs.

Ethical Considerations

The implementation of new technologies in educational settings brings with it important ethical considerations, particularly in terms of data privacy and informed consent.

- Data Privacy: The collection of data through digital tools such as AI, AR, and VR must be handled with extreme care. It is essential to ensure that students' personal data is protected and that compliance with current privacy and data protection regulations, such as the General Data Protection Regulation (GDPR) in Europe, is maintained.
- Informed Consent: Before participating in the study, all students must be fully informed about the nature of the study, the technologies to be used, the potential risks and benefits, and how their personal data will be managed. Informed consent must be voluntary and explicit, ensuring that students fully understand what their participation entails.
- Accessibility and Equity: It is crucial to ensure that all students have equitable access to the technologies used. Any economic, technical, or physical barriers that may limit certain students' access must be addressed to avoid inequalities in the educational experience.

Conclusions

In the course "Formal Representation of Space," emerging technologies such as artificial intelligence (AI), augmented reality (AR), virtual reality (VR), and the Metaverse were integrated into teaching, promoting interdisciplinary and international learning through the COIL methodology. This approach allowed students to collaborate effectively with peers from different disciplines and countries, enriching their educational experience and developing key competencies for their professional formation.

During the academic period, students worked in multicultural teams to design and visualize architectural spaces, using AR and VR to enhance three-dimensional understanding and creativity. The results reflect a significant increase in student engagement and motivation, as well as an improvement in their technical and collaborative skills.

Among the main facilitators identified in this innovative methodology are: • Access to Advanced Technologies: The availability of tools such as AR, VR, and the Metaverse facilitated the creation of immersive learning environments that enhanced spatial understanding and creative design.

- International Collaboration: Participation in the COIL methodology allowed students to develop intercultural skills and work in a globalized environment, enriching their academic and professional perspective. However, some challenges were also identified:
- Availability of Resources: The implementation of these technologies requires adequate infrastructure, and some students faced difficulties in accessing the necessary resources.
- Adaptation Time: The use of new technologies required an adaptation period for both students and teachers, which initially slowed down the teaching-learning process.
- Finally, students presented design proposals and solutions to architectural problems, which were evaluated and adjusted in collaboration with their international peers. These experiences have laid the foundation for future implementations of these technologies in other contexts and disciplines, with the potential to profoundly transform higher education.

Limitations and Future Research

This study presents several limitations. The sample size was relatively small (54 students) and limited to creative disciplines, which may restrict the generalization of the results to other areas of knowledge. Additionally, the study was conducted over an academic period, limiting the evaluation of the long-term impact of the implemented technologies. External factors, such as the students' prior familiarity with digital technologies, may have also influenced the results.

Future research should expand the scope of this study to other disciplines and increase the sample size to validate the effectiveness of emerging technologies in different educational contexts. Longitudinal studies will be crucial to evaluate the long-term impact of these technologies on the development of professional competencies. Furthermore, it is recommended to explore the combination of AI, AR, VR, and the Metaverse with other innovative pedagogical methodologies and analyze how these technologies prepare students for the global job market. Additional research should also address ethical and privacy considerations, ensuring that the use of technologies in education is safe and equitable.

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