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ARTICLE / ARTÍCULO

Immersive learning ecosystems: The synergy of ChatGPT and metaverse in a higher education institute of technology in Ecuador

Ecosistemas de aprendizaje inmersivo: sinergia ChatGPT y metaverso en Institutos Superiores Tecnológicos del Ecuador

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Abstract: This study explores the challenges and benefits of integrating ChatGPT and the metaverse at a higher education institute of technology in Ecuador, with an emphasis on two barriers—the digital divide and lack of training—that limit access to and the effectiveness of innovative teaching methods. Using a qualitative methodology, data was collected through semi-structured interviews, demonstration classes, and structured observation by involving 12 students and 3 professors. During the practical activities, participants shared their perceptions and experiences. The findings highlight that the metaverse facilitates the understanding of complex concepts and encourages collaboration in simulated environments, while ChatGPT promotes autonomy and personalization in learning. The use of ChatGPT to solve basic queries also reduced the teaching load and allowed professors to focus on facilitation and evaluation of student performance. However, challenges such as limited connectivity, inadequate equipment, and lack of prior experience hindered initial implementation. The participants emphasized that pedagogical guidelines were helpful in structuring the use of these tools. The study concludes that the synergy between ChatGPT and metaverse can transform higher education. However, it is necessary to provide specialized training and have inclusive policies to ensure equity and effectiveness in students' access to these emerging technologies.

Keywords: Generative Artificial Intelligence, ChatGPT, Metaverse, Higher Education, Case Study.

Resumen: La investigación explora los desafíos y beneficios de integrar ChatGPT y el metaverso en Institutos Superiores Tecnológicos en Ecuador, con énfasis en la brecha digital y la falta de capacitación en estas tecnologías. Estas barreras limitan el acceso y la eficacia de métodos innovadores de enseñanza. A través de una metodología cualitativa, se recopiló datos mediante entrevistas semiestructuradas, clases demostrativas y observación estructurada, involucrando a 12 estudiantes y 3 docentes. Durante las actividades prácticas, los participantes compartieron sus percepciones y experiencias. Los hallazgos destacan que el metaverso facilita la comprensión de conceptos complejos y fomenta la colaboración en entornos simulados, mientras que ChatGPT impulsa la autonomía y personalización del aprendizaje. Sin embargo, factores como conectividad limitada, equipos inadecuados y falta de experiencia previa dificultaron la implementación inicial. Se subraya la importancia de las guías pedagógicas para estructurar el uso de estas herramientas. La investigación concluye que la sinergia entre ChatGPT y el metaverso transforma la Educación Superior, requiriendo capacitaciones específicas y políticas inclusivas para garantizar equidad y efectividad en el acceso a estas tecnologías emergentes.

Palabras clave: Inteligencia Artificial Generativa, ChatGPT, Metaverso, Educación Superior, Estudio de caso.

1. Introduction

In a world transforming rapidly due to digital technologies, higher education institutions face the challenge of adapting their teaching methodologies to the demands of an interconnected and highly technological environment (Romero Carbonell et al., 2023). The implementation of cutting-edge technologies presents significant challenges, especially in Latin America, where factors such as infrastructure, educational investment, and government policies determine adoption capabilities. According to a UNESCO report (2023), 85% of universities globally report difficulties related to the lack of adequate infrastructure. In the Latin American context, these limitations can be even more pronounced due to economic inequalities, technological limitations, and traditional pedagogies (Observatory of the Monterrey Institute of Technology, 2024; Zapata, 2020). This situation calls for innovative approaches that guarantee equitable access to technology and inclusive pedagogical strategies aligned with the demands of the 21st century (Albuja Loachamín et al., 2023).

The digital divide, which is especially pronounced in rural areas, restricts access to technological tools that are essential for effective participation in today's knowledge-oriented society. This inequality affects both students and professors, who struggle due to heavy workloads, limited resources, and insufficient training in emerging technologies and modern pedagogical methodologies (Bonilla & Muñoz, 2022; Zapata, 2020). Thus, there is a need for educational policies that promote professional development of professors and equity in access to technologies.

In this context, immersive learning ecosystems emerge as a promising solution. This concept refers to educational environments that integrate advanced technologies such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) to offer multisensory and adaptive experiences. These tools allow students to interact with simulated scenarios, promoting practical, collaborative, and personalized learning, which is particularly valuable in disciplines that require an applied understanding of complex concepts. These platforms encourage greater participation and the cultivation of practical and analytical skills (Fabris et al., 2019; UNESCO, 2023).

The combination of ChatGPT and the metaverse represents a transformative synergy in this landscape. ChatGPT, as an AI-based language model, facilitates personalized interactions in real time, while the metaverse creates immersive environments ideal for collaboration and experimentation (Barráez-Herrera, 2022). Wei et al. (2022) conducted a systematic review of virtual reality research and found that immersive environments improved the communication skills of participants. These technologies have the potential to overcome infrastructural and resource limitations in institutions with limited resources, as is the case with many universities in Ecuador (Castellá, 2023; Torres Vargas, 2023).

Recent literature has explored the potential of these tools from different perspectives. In the Ecuadorian context, theoretical and practical research offers a framework for addressing specific challenges related to infrastructural and educational equity. For example, ChatGPT could provide personalized tutoring in rural areas, while the metaverse could generate simulated spaces that overcome the physical and logistical limitations of many institutions. ChatGPT has high potential as a virtual tutor within the metaverse, allowing for personalized learning and improved interaction

between students and educational content. However, Galli and Kanobel (2023) emphasize the importance of teacher supervision to ensure the quality and accuracy of the responses generated, highlighting current technological limitations. On the other hand, González Alcaide (2024) points out that the combination of these technologies fosters collaborative and creative educational environments, although he warns of the ethical and privacy risks associated with their implementation.

From a teaching perspective, it is clear that adopting these tools requires significant changes in pedagogical practices, including continuing professor training and curriculum adaptation. Similarly, Jofre (2023) stresses the importance of ensuring equitable access to these technologies to prevent technological inequalities from perpetuating existing gaps in the education system. In turn, Mollick (2024) warns that excessive use of ChatGPT could turn it into a “crutch,” inhibiting the development of critical and analytical skills. Instead, he proposes strategic integration that promotes active learning and critical thinking.

In terms of innovation, the EdChat project combines ChatGPT with traditional chatbot frameworks to offer improved student support. This approach not only increases learning efficiency in virtual environments but also encourages closer interaction between students and educational resources (Wang et al., 2023). Complementarily, Malinka et al. (2023) highlight the impact of ChatGPT in technical areas such as programming, emphasizing the need to adjust assessment methodologies to ensure that these tools are used as support and not as a substitute for academic effort.

The cultural influence of these technologies has also been studied. López and Rahwan (2024) analyze how terms generated by language models such as ChatGPT are being adopted into everyday vocabulary, warning of possible implications for linguistic and cultural diversity, especially in academic contexts. They emphasize the importance of maintaining diversity in the development of these tools, arguing that the monopolization of language models could limit the pedagogical and cultural perspectives available.

Despite its potential benefits, the implementation of ChatGPT and the metaverse in Ecuadorian higher education faces significant barriers related to technological infrastructure, access equity, and professor training. Strategies such as investing in digital infrastructure, developing continuing training programs for professors in emerging technologies, and promoting inclusive public policies are essential to overcoming these limitations. These actions can facilitate a more inclusive and effective adoption of these tools in the national educational context. In addition, these limitations highlight the need for empirical studies that explore the applicability and adaptability of these technologies in local contexts, as well as investments in equipment acquisition and training that would enable professors and students to take full advantage of these tools (López-Belmonte et al., 2023).

This research aims to analyze the perceptions and experiences of professors and students regarding the synergy between ChatGPT and the metaverse in teaching-learning processes in a higher education institute of technology in Ecuador. A qualitative approach was chosen in order to identify the technological, pedagogical, and institutional challenges associated with the implementation of these tools, as well as to evaluate their impact on education dynamics. The following research questions

are posed: What are the perceptions and experiences of professors and students regarding the use of ChatGPT and the metaverse in higher education settings? How does the synergy between ChatGPT and the metaverse influence the dynamics of teaching-learning processes in higher education? What are the technological and pedagogical challenges for the use of ChatGPT and the metaverse in teaching-learning processes in higher education?

The objective of this study is to understand how ChatGPT and the metaverse interact together and how they affect teaching-learning processes. The relevance of this research lies in addressing an emerging and little-explored issue in Ecuador. Currently, the use of technologies such as ChatGPT and the metaverse has not been systematically evaluated, leaving a gap in our understanding of their impact on the personalization and effectiveness of learning. The findings of this study can contribute significantly to the development of guidelines that promote the effective and contextualized adoption of these tools. Likewise, this research can be used as a basis for inclusive educational policies that promote equity in access to immersive technologies and strengthen professor training, which are key factors for an educational system aligned with the demands of the 21st century.

2. Methodology

To address the study objectives, we used a qualitative approach that would allow us to explore and understand the experiences of students and professors in using ChatGPT and the metaverse in immersive learning environments. As qualitative methodology allows for an in-depth analysis of the perceptions and dynamics of interactions between actors, it is apt for this exploratory and descriptive research (Creswell & Poth, 2018).

2.1. Research design

The research design used was phenomenological, focusing on describing and analyzing the experiences and meanings attributed by participants to the use of ChatGPT and the metaverse in their teaching-learning processes. This design was particularly relevant for understanding the subjects' experiences in specific contexts, allowing for a detailed analysis of their perceptions and emotions in relation to educational technology (Van Manen, 2016).

2.2. Participants

The participants, comprising 3 professors and 12 students, were selected through purposive sampling from the administration program at the institution chosen for the case study. The inclusion criteria considered previous experience with ChatGPT and metaverse and the willingness to share perceptions in a detailed and reflective manner. In total, six students and three professors were interviewed, which ensured diversity and representativeness in the data obtained (Patton, 2015). This criterion allowed us to obtain meaningful perspectives from the direct users of these technologies, enriching the qualitative analysis (Merriam & Tisdell, 2015).

2.3. Data collection

Three main techniques were used for data collection: semi-structured interviews, demonstration classes, and structured observation.

- Semi-structured interviews: Interviews were conducted individually with a pre-designed script to explore specific topics related to the experience of use, benefits, and challenges in using ChatGPT and the metaverse. The questions addressed aspects such as the perception of personalization in learning, impact on motivation and engagement, and the technological and pedagogical challenges experienced. Each interview lasted approximately 45 minutes and was recorded and transcribed for later analysis (Kvale, 2008).
- Demonstration classes: Class activities were organized into two periods, marked by different objectives to be achieved and the use of specific technological tools. In the first period, independent work, information gathering, and critical thinking were planned. To this end, students used their mobile phones to access ChatGPT to obtain information related to the topic to be discussed in class (see Figure 1). In the second period, activities were carried out to apply the theory researched. The knowledge acquired was put into practice through the use of metaverse glasses¹, simulating work scenarios in academic contexts. These activities promoted the development of critical analysis, decision-making, and teamwork (see Figure 1). In both phases, support was provided by a professor and three students from the software program.

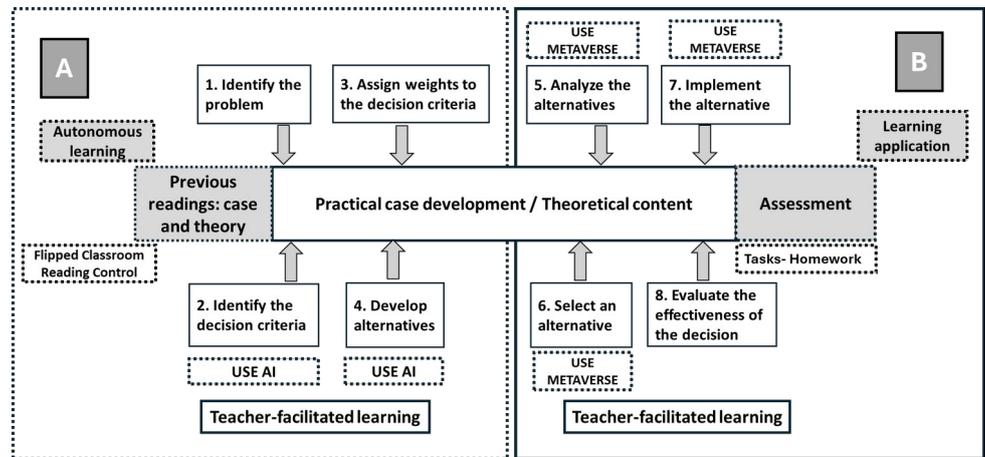


Figure 1. Class design.

- Structured observation: Each demonstration class was attended by an observer professor, who recorded specific behaviors such as frequency of participation, use of technologies, collaborative dynamics among students, and classroom management by the facilitating professor. This technique was complemented by field notes, which documented contextual and emotional aspects perceived in the participants. Structured observation provided a comprehensive view of the implementation of these technologies in the classroom and their impact on learning dynamics (Angrosino, 2012).

¹ Meta Quest 3 - Dual RGB camera with depth projector to combine physical and virtual spaces - 4K+ Infinite Display 2064x2208 pixels per eye with 90 Hz refresh rate (120 Hz in experimental mode) - Ring-Free Controllers, TruTouch Haptic Feedback.

2.4. Data analysis

The digital information collected in the interviews with students and professors was converted to text and processed using the Atlas.ti-24 software. Thematic and hermeneutic analysis was performed on the data, following the stages proposed by Braun and Clarke (2006): familiarization with the data, generation of initial codes, searching for themes, reviewing themes, and defining themes.

In the first stage, interview transcripts and observation notes were reviewed to identify relevant patterns and concepts. Subsequently, specific codes were developed that grouped the most significant ideas and experiences around the benefits, challenges, and perceptions of using ChatGPT and the metaverse. These codes were organized into themes and subthemes, which facilitated the interpretation of the results and the creation of solid analytical categories that reflected the participants' experience.

2.5. Case study

Instituto Superior Tecnológico "ISMAC" ("ISMAC" Higher Institute of Technology) was chosen as the site of case study due to its representativeness within the Ecuadorian higher education system, based on its number of students and the range of courses it offers.

This choice facilitated the analysis of teaching and learning processes. In addition, three of the authors of this study are employed at the institution in roles related to the research topic. It should be noted that ISMAC students belong to the low-income socioeconomic group and live in rural or suburban areas, where the digital divide is significant compared to most universities.

2.6. Ethical considerations

This study conforms to the fundamental ethical principles of research. Informed consent was obtained from each participant, with the guarantee of confidentiality and anonymity. Participants were informed about the study objective and their right to withdraw at any time without repercussions. Likewise, data privacy was ensured and participants were told that the results would be used exclusively for academic purposes (Flick, 2018).

2.7. Study limitations

While this study provides a detailed perspective on the impact of the synergy between ChatGPT and the metaverse on immersive education in Ecuador, the qualitative methodology and the small sample size limit the generalization of the results to other contexts or educational institutions. However, the findings provide a relevant basis for future research and the development of educational policies in this area.

3. Results

This case study revealed a significant range of experiences and perceptions regarding the use of immersive technologies and AI tools in the context of teaching and learning.

3.1. Perceptions and experiences of professors and students regarding the use of ChatGPT and the metaverse in higher education settings

An initial finding reflected perceptions about knowledge of these technological tools, with professors and students demonstrating a basic level of knowledge and use of ChatGPT. The level of knowledge of other technologies such as Gemini, Ideogram, and Copilot was even more limited. Likewise, a general lack of knowledge about the metaverse was observed among students and professors, especially in educational settings.

Students' experiences

The students were organized into groups and asked to solve a case or a math problem. An initial challenge arose during the search for information. The professors proposed a general initial prompt² as a basis for the search. The students took this input, but then began to perform other unscheduled searches, which forced them to redirect the search and come up with new prompts. One student commented:

«Initially, I got lost. I think I typed the directions wrong and the chat started showing me things I didn't understand» (Interview with student E2, August 7, 2024)

In addition, there were problems with the Internet signal, which was very slow and had several interruptions, forcing a change of network in order to continue with the class. It should also be noted that the students' cell phones varied greatly in terms of their technological characteristics, which led to disparities in the speed at which information could be obtained. Two students pointed this out:

"The Internet affected us. We had to keep entering information all the time, and it took a long time to respond" (Interview with student E1, August 7, 2024).

"My cell phone is old and sometimes causes me problems when I use it. We had to use a classmate's cell phone to quickly look up the information" (Interview with student E4, August 8, 2024).

As for the metaverse, the initial experiences were marked by unfamiliarity with the glasses and controllers. Consequently, the students required considerable time to get comfortable with the tool and use it without problems. During this phase, there were also interruptions due to issues such as not quickly locating the environment where they were supposed to work, selecting avatars, and the various resources they could use to interact with others in the virtual reality, such as whiteboards, annotations, or manipulating three-dimensional objects. One student pointed out:

² An AI prompt is an instruction or set of words provided to an AI system to perform a specific task, such as generating text, images, or code. The clarity and precision of the prompt determine the quality of the model's response - Hostinger. (2023, September 5).

"It was a little difficult at the beginning. I was lost, but slowly I realized how it worked and I calmed down" (Interview with student E3, August 7, 2024).

Professors' experiences

The professors developed and shared learning guidelines with students. Planning the guidelines led the professors to rethink the traditional approaches they had been using in their classes, which in turn led them to rethink activities for independent learning and for using technological tools. Before implementing the demonstration classes, participating professors received basic training in the use of metaverse equipment. Like the students, the professors faced problems while using the metaverse equipment as its use requires the development of digital skills. One professor pointed out:

"This is a new experience for me. I found these glasses interesting. It's a whole new world for me. You have to learn how to use them properly before you can teach others. (Interview with professor D3, July 24, 2024).

The lack of previous experience with immersive technologies was a considerable barrier for some students and professors, especially in the use of devices such as virtual reality glasses and in the formulation of effective questions for the AI tool (known as prompt engineering)³. This adaptation process was described as challenging by professors, who expressed the need for specialized training to optimize its integration in the classroom. One professor stated:

"I see that these tools are revolutionizing the way students can interact. They can review theory and interact in a practical way. This is good for their learning experience. But it is difficult for me to use these tools due to my lack of specialized training" (Interview with professor D1, July 24, 2024).

The teaching guidelines played a fundamental role in facilitating a comprehensive educational experience within the framework of the implementation of immersive technologies. This tool contributed significantly to meaningful learning and the development of social skills in students. One professor shared her experience, stating:

"The guidelines were very helpful. At the beginning I was hesitant, I was lost, but then with the guidelines, I was able to teach the class without any problems" (Interview with professor D2, July 24, 2024).

This testimony highlights the value of learning guidelines as a key resource in guiding and executing pedagogical activities.

Professors also highlighted the structure and clarity provided by the learning guidelines, elements that proved essential to the success of the teaching process. Under the activity instructions outlined in these guidelines, professors were able to better organize and deliver their classes, thereby promoting a more effective educational environment. In addition, it was emphasized that the guidelines fostered student autonomy by including specific indications that allowed them to make informed decisions, strengthening their capacity for independent and critical learning. One professor pointed out:

³ An AI prompt is an instruction or set of words provided to an AI system to perform a specific task, such as generating text, images, or code. The clarity and precision of the prompt determine the quality of the model's response - Hostinger. (2023, September 5)

"The guidelines were like a map. We all knew what needed to be done in class, and when questions arose, we referred back to the guidelines to continue and guide the students" (Interview with professor D1, July 24, 2024).

Another aspect highlighted by professors was the influence of the learning guidelines on the personalization and adaptation of the educational context. The guidelines allowed the content and teaching strategies to be adjusted to the specific needs of each group of students, taking into account their prior knowledge and contextual particularities. This flexibility helped improve the relevance and effectiveness of the educational processes, promoting a more equitable and meaningful experience for all participants.

The use of ChatGPT did not pose a major problem, as professors had previous experience with it. Considerable time was spent on the creation of prompts to be used by students. Several were proposed for each stage of the information search and then for decision-making. One professor stated:

"We had already been using ChatGPT before, even with the same students. I realize that the prompts need to be well crafted. That's key" (Interview with professor D3, July 24, 2024).

Classroom management presented some monitoring challenges for the professors due to their lack of experience in using the metaverse control tool from the laptop that was used as the monitoring center. For example, some voice commands issued from the professor's microphone were not clearly understood by the students. These technical audio issues delayed the progress of the class and created situations where students did not know how to act. Once the initial technological problems were overcome, the class proceeded normally as planned in the learning guidelines.

3.2. Influence of the synergy between ChatGPT and the metaverse on the dynamics of teaching-learning processes in higher education

The combination of immersive environments promoted dynamic, student-centered interactions, prioritizing personalized learning and the development of autonomous skills. We highlight some aspects of the noted influence.

Autonomy and personalization in learning

ChatGPT served as an academic assistant that enhanced students' skills in efficiently searching for and organizing information. Initially, students worked individually and then in groups, with little influence from professors, which allowed them to conduct personalized searches, collect data, and delve deeper into specific topics. This approach fostered autonomy in learning, improving the ability to make informed decisions and solve problems. One student pointed out:

"I was able to progress at my own pace. I researched some things that I didn't fully understand. I didn't need to ask the professor to explain things to me. It gave me the confidence to learn on my own" (Interview with student E6, August 8, 2024).

Subsequently, students applied the knowledge acquired with ChatGPT in the metaverse, interacting in three-dimensional scenarios that facilitated the

understanding of complex concepts. These practical experiences enriched their academic training and strengthened their analytical skills. One student described their experience as follows:

"It was like being in a real company. We were able to apply what we had researched beforehand in ChatGPT without the professor's assistance. The class was more dynamic and useful for my training" (Interview with student E5, August 8, 2024).

For professors, ChatGPT proved to be a key tool for designing personalized activities for student groups. It also allowed them to ask specific questions, access relevant information, and provide effective feedback on case studies. One professor stated:

"This tool allows you to ask specific questions and explore possible answers in a flexible way. It was very useful for my classes" (Interview with professor D1, July 24, 2024).

However, familiarity with these technologies varied among professors, emphasizing the need for continuing training to maximize the potential of AI in education.

Collaborative learning

The metaverse promoted collaborative learning, giving students the opportunity to interact in real time and work on group projects, which encouraged joint problem solving and the discussion of ideas in a simulated environment. This learning model promoted the co-creation of knowledge, strengthening key social skills such as cooperation, communication, and teamwork. One student highlighted the importance of this approach when describing their experience in the metaverse:

"I was able to work effectively as part of a team with my classmates. I think it was a good experience" (Interview with student E3, August 7, 2024).

Reconfiguration of professor and student roles

The synergy between ChatGPT and the metaverse changed the dynamics of interaction between students and professors. As students were able to obtain instant answers and constant self-feedback, their dependence on repeated professor consultation was reduced. This set the stage for true student-centered learning. One student commented:

"The good thing was that we practically taught ourselves. The professor did help, but we did most of it ourselves" (Interview with student E1, August 7, 2024).

In turn, professors focused on more complex tasks, such as creating interactive projects and qualitatively analyzing student performance in class. This change allowed professors to take on the role of learning facilitators, focusing on personalized support and supervising the progress of the working groups involved in the demonstration classes. One professor commented on this development:

"With AI I feel that I have been freed from routine tasks. It frees up more time for other activities that I have always wanted to do" (Interview with professor D3, July 24, 2024).

On the other hand, the use of the metaverse allowed professors to design learning environments tailored to the levels and needs of the working groups, increasing their motivation and commitment to the educational process. In addition, it offered the flexibility to make modifications in real time, adjusting learning experiences according to the students' responses, generating a flexible and adaptable educational proposal.

Development of technological and soft skills

Interaction with AI tools and immersive environments proved to be a transformative educational experience, especially in fostering specific skills in students. In the case of ChatGPT, the importance of prompt engineering was realized, as most students initially asked very general questions that limited the AI's potential to generate personalized and specific responses. This challenge was overcome through professor support, leading to an improvement in the quality of the questions, which helped obtain more accurate information to solve the case or math exercises. This process not only optimized learning but also developed key skills such as the ability to formulate clear and specific questions, critical thinking to evaluate answers, and adaptability to interact with the tool in an iterative and adaptive manner.

The metaverse facilitated practical learning by providing the possibility of simulating professional contexts. Students determined that the metaverse allowed them to acquire applied skills such as collaboration, problem solving, and effective communication. One student commented:

"Learning how to use these technologies allowed me to understand how they apply to my future work" (Interview with student E4, August 8, 2024).

These skills, aligned with the demands of today's job market, strengthened collaborative learning and responsible use of the metaverse.

Quality of the educational process

The personalization of learning through the synergy between ChatGPT and the metaverse improved educational quality by increasing student engagement and promoting independent and relevant learning. This adaptive model allowed students to progress at their own pace, receive instant feedback, and apply theoretical knowledge in simulated contexts. One student stated:

"The important benefit I notice in learning about the metaverse is to innovate and learn regardless of location" (Interview with student E2, August 7, 2024).

Access to personalized information encouraged skills such as critical thinking and effective questioning, while virtual scenarios fostered collaboration and real-time decision-making. These experiences also facilitated the understanding of complex concepts and promoted the development of technological and interpersonal skills. As one student pointed out:

"I learned to analyze AI responses, not just copy and paste, but to analyze the information" (Interview with student E5, August 8, 2024).

Professors and students agreed that the combination of these tools allowed for the design of dynamic and contextual educational experiences that enriched research, analysis, and classroom participation. Likewise, the ability to visualize and manipulate three-dimensional objects in real time promoted practical and meaningful learning, thus contributing to the overall improvement of the educational process.

3.3. Technological and pedagogical challenges for the implementation of ChatGPT and the metaverse in teaching-learning processes in Higher Education

Combining AI and immersive environments promoted more dynamic and student-centered interactions, fostering a pedagogical practice that prioritized the personalization of learning and the development of autonomous skills. However, implementing this form of AI-based digital learning in higher education institutions in Ecuador is challenging.

Technological challenges

The effort to combine ChatGPT and the metaverse in this case study revealed significant technological challenges that limited effective implementation. One of the main problems identified was insufficient technological infrastructure, especially in terms of Internet connectivity. Slow and unstable connectivity significantly affected the continuity of interactions in immersive environments, making it difficult to access and take full advantage of the technological tools available. Thus, a stable infrastructure is essential for the success of such innovations.

Students' and professors' lack of prior experience with immersive and AI tools represented a major obstacle. For example, interaction with ChatGPT required specific skills, such as prompt engineering, that were initially undeveloped. Similarly, using the metaverse demanded technical knowledge to handle devices such as virtual reality glasses. This highlighted the need to provide specialized training to both students and professors to ensure efficient and responsible use of these tools.

Overall, these findings emphasized that overcoming technological and training barriers is imperative to maximize the educational potential of the synergy between ChatGPT and the metaverse in Ecuadorian higher education.

Pedagogical challenges

Students and professors agreed on the importance of consolidating ChatGPT as a key academic assistant for searching, gathering and organizing information, fostering autonomy in learning, informed decision making, and problem solving. One student said:

"I hope to continue with all the activities we did in the demonstration class. It was a good experience. It helped us, especially ChatGPT" (Interview with student E6, August 8, 2024).

The need for a clear methodology for the combined use of ChatGPT and the metaverse was emphasized, along with practical guidelines that facilitate independent and group work. This includes guidelines on equipment management and the potential of each tool. One student pointed out:

"It would be good to develop more cases in the future where we can simulate the reality of a profession" (Interview with student E2, August 7, 2024).

In addition, the value of collaborative work was highlighted, where real-time interactions and group projects helped the development of social skills. One student stated:

"I liked working in groups because it was more effective. I learned a lot"
(Interview with student E3, 7 August 2024).

The use of ChatGPT to solve basic queries also reduced the teaching load, allowing professors to take on roles more oriented to facilitation. However, customizing educational environments according to the needs of each group and aligning them with innovative pedagogies was challenging. Professors as well as students stressed the importance of continuing training in immersive tools and AI, in addition to updating institutional technological infrastructures. In summary, the study reflects the benefits and challenges of integrating ChatGPT and the metaverse in higher education, highlighting the need for resources, training, and clear methodologies to maximize their impact on learning ecosystems.

4. Conclusion-Discussion

This research shows how ChatGPT and the metaverse could transform education in Ecuador's higher institutes of technology. These tools reconfigure teaching towards a personalized, collaborative and student-centered model.

By integrating AI and immersive environments, innovative pedagogical strategies are promoted to partially overcome the technological and pedagogical barriers in the educational system.

This study emphasizes the effectiveness of ChatGPT in personalizing learning, facilitating immediate responses that foster student autonomy. Its recurrent use improved students' confidence in formulating structured questions, leading to the development of critical and analytical skills. In addition, the metaverse stands out as a key tool for simulating professional scenarios by promoting collaboration and problem solving in three-dimensional environments, strengthening practical and experiential learning. Both technologies worked synergistically to enrich teaching-learning dynamics and student skills.

This study shows how ChatGPT and the metaverse impact the autonomy and personalization of learning and reconfigure educational roles. Students become active agents of learning, while professors take on roles as facilitators and designers of meaningful experiences. This role modification supports adaptation to the individual needs of students, promoting more inclusive and effective learning. Moreover, these technologies are especially beneficial in diverse and multicultural educational environments, consolidating their role in the modernization of education.

The use of ChatGPT reveals a significant learning curve for students and professors, especially in terms of formulating effective questions (prompts). This aspect, identified as an initial challenge, was overcome by the support of professors and the design of pedagogical guidelines for using the tool. The training sessions, integrated into the development of the project, were key to mitigate the initial resistance to technological change, encouraging greater acceptance and use of digital tools.

The immersive experiences in the metaverse, although challenging in terms of technical implementation, allowed students to develop technological and soft skills such as collaboration, conflict resolution, and effective communication. These results are consistent with studies such as Wei et al. (2022) validating the efficacy of immersive environments to reinforce practical and experiential learning.

Comparisons with previous studies reinforce the benefits of these technologies. Galli and Kanobel (2023) highlight that ChatGPT personalizes learning, while Mollick (2024) stresses the importance of strategies that foster critical thinking. In this study, ChatGPT proved to be essential for fostering student autonomy, and the metaverse served as a catalyst for collaborative learning. In addition, these tools proved to be highly adaptable to the specific needs of students, indicating their applicability in diverse educational contexts and consolidating their transformative potential in education.

From a theoretical perspective, these results reinforce the applicability of social constructivism in technologized educational environments. The interaction between students and technological tools, mediated by professors, validates the constructivist approach by allowing knowledge to be constructed in an active and contextual manner. In addition, the combination of ChatGPT and the metaverse broadens the scope of experiential learning, integrating emerging technologies that facilitate practical exploration of theoretical concepts.

The findings of this study highlight the importance of implementing educational policies that promote the continuing training of professors in the use of AI tools and immersive environments. These technologies require constant training, especially in the Ecuadorian context, where technological inequalities limit equitable access to pedagogical innovations. Ensuring an adequate and accessible technological infrastructure is crucial to maximize the impact of these tools in education and overcome existing barriers.

The study results highlight the need to design pedagogical interventions that consider both cultural diversity and the specific needs of students. ChatGPT and metaverse offer the possibility of personalizing learning experiences according to the socioeconomic and cultural context of students, making education more inclusive and effective. In this way, technological tools make it possible to close learning gaps, especially in communities where access to resources is limited.

However, in addition to the significant contributions, the study has limitations derived from its qualitative design. The sample of participants, although representative of the institutional context analyzed, does not allow generalizing the results to other educational institutions with different characteristics. Likewise, technological restrictions, such as limited connectivity and differences in access to technological devices, partially conditioned the implementation of the planned activities, affecting the full scope of the tools studied.

Future research could expand the sample size to analyze how these technologies impact different contexts, both in urban and rural universities. It would also be relevant to explore how tools such as ChatGPT and the metaverse can influence specific disciplines, such as technical sciences and humanities, in order to identify adaptive pedagogical approaches. Furthermore, it is essential to investigate how these

technologies can be used to close learning gaps for students with special educational needs, providing more inclusive and accessible solutions.

The results obtained corroborate that the integration of ChatGPT and the metaverse generates a favorable impact on teaching-learning processes. These technologies favor learning personalization, promote the development of technological skills, enhance collaboration, and expand pedagogical possibilities towards more inclusive and adaptive educational models. This approach not only responds to the current demands of the educational system, but also anticipates future transformations, consolidating a learning model that coordinates technology with human needs. The implementation of ChatGPT and the metaverse in the case study reconfigured traditional teaching methods, thus optimizing the students' learning experience.

5. References

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