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ORIGINAL

Innovación educativa en universidades latinoamericanas: Explorando el potencial del metaverso en la enseñanza de educación superior

Educational innovation in Latin American universities: Exploring the potential of the metaverse in higher education teaching

Juan de Jesús Alvarado Ortiz[1], Teresa del Carmen Cabrera Gómez[2], Luis Germán Sánchez Méndez[3], Katherine Adriana Merino Villa[4], Gabriela Margarita Loza Casa[5], Jefferson Olimpo Gutierrez Bastidas[6]

[1]Universidad Virtual del Estado de Guanajuato, Guanajuato. México.
[2]Instituto Tecnológico de Tapachula, Docente. Tapachula de Córdova. México.
[3]Universidad Autónoma del Estado de Quintana Roo, Chetumal. México.
[4]Escuela Superior Politécnica de Chimborazo, Docente. Riobamba. Ecuador.
[5]Universidad Regional Amazonica Ikiam, Tena. Ecuador.
[6]Universidad Tech, Milagro. Ecuador.

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Corresponding author: Juan de Jesús Alvarado Ortiz

ABSTRACT

The metaverse was conceptualized as an immersive environment capable of transforming learning experiences through three-dimensional interaction, virtual collaboration, and educational simulation. The main objective of this study was to analyze how academic participation, student performance, and digital equity were influenced by the integration of the metaverse in Latin American higher education. A mixed-methods sequential design was applied; quantitative instruments were designed and validated according to the core variables, achieving strong reliability levels, and surveys were administered to 600 students. Additionally, semi-structured interviews and focus groups were conducted with students and instructors to explore perceptions in greater depth, followed by systematic open, axial, and selective coding. Quantitative results indicated that the metaverse increased participation and motivation, with mean values above 3,30; however, improvements in performance were moderate and uneven across participants. Significant digital equity gaps related to device access and connectivity also emerged, limiting the scope of immersive activities. Qualitative findings reinforced these patterns, revealing that participants perceived clear pedagogical benefits but experienced persistent technological barriers and limited training. Overall, the results showed that the metaverse had substantial potential to enhance participation and learning, although its effectiveness depended on institutional support, technological conditions, and users' digital literacy levels.

Keywords: Metaverse; Immersive Learning; Digital Equity; Academic Participation; Higher Education.

RESUMEN

El metaverso se conceptualizó como un entorno inmersivo capaz de transformar las experiencias de aprendizaje mediante la interacción tridimensional, la colaboración virtual y la simulación educativa. El estudio tuvo como objetivo analizar cómo la participación académica, el rendimiento estudiantil y la equidad digital se vieron influenciados por la incorporación del metaverso en la educación superior latinoamericana. La metodología combinó un enfoque mixto secuencial: primero se diseñaron y validaron instrumentos cuantitativos alineados

con las tres variables principales, obteniendo adecuados niveles de confiabilidad; posteriormente, se aplicaron encuestas a 600 estudiantes. De forma complementaria, se realizaron entrevistas semiestructuradas y grupos focales para profundizar en las percepciones estudiantiles y docentes, seguidos de un proceso sistemático de codificación abierta, axial y selectiva. Los resultados cuantitativos mostraron que el metaverso incrementó la participación y la motivación, con medias superiores a 3,30; sin embargo, el rendimiento evidenció mejoras moderadas y heterogéneas. Asimismo, se identificaron brechas de equidad digital relacionadas con acceso tecnológico y conectividad, que limitaron el alcance de las experiencias inmersivas. Los hallazgos cualitativos reforzaron estas tendencias, indicando que los estudiantes percibieron beneficios pedagógicos, pero enfrentaron obstáculos estructurales y falta de formación tecnológica. En conjunto, los resultados demostraron que el metaverso tuvo un potencial significativo para enriquecer la participación y el aprendizaje, aunque su efectividad dependió de las condiciones institucionales y del nivel de alfabetización digital.

Palabras clave: Metaverso; Aprendizaje Inmersivo; Equidad Digital; Participación Académica; Educación Superior.

INTRODUCTION

The central theme of this research is pedagogical innovation in Latin American universities through the use of the metaverse in higher education. This topic falls within the convergence of immersive technologies and contemporary pedagogies, and explores how three-dimensional virtual environments can transform the university learning experience.[1,2] The adoption of the metaverse in higher education represents an emerging field of exploration for rethinking teaching practices, access, participation, and student collaboration.

In this context, many Latin American universities are immersed in digital transformation processes and are seeking innovative pedagogical solutions to address challenges of equity, infrastructure, and academic quality.[3,4] The metaverse therefore presents itself as a tool with strong transformative potential: it can create immersive spaces, help reduce geographical inequalities, and offer personalized educational experiences.[5,6] Its integration is not only technological, but also involves the redesign of curricula and teaching strategies.

This issue is important because higher education in Latin America faces persistent challenges: unequal access, lack of technological resources, high dropout rates, and traditional teaching models that are inadequate for the 21st century.[7,8] The introduction of innovations such as the metaverse could help overcome these obstacles by creating more inclusive and motivating environments and promoting student success and perseverance. It also encourages internationalization and collaboration between universities through shared virtual spaces.[9,10]

However, the use of the metaverse can also pose a significant problem: many institutions lack the technical capacity, faculty training, and adequate infrastructure to implement it effectively, which could exacerbate the existing digital divide.[11,12] If this problem is not adequately addressed, this innovation could benefit only the most technologically advanced universities, leaving behind less developed institutions and generating educational inequalities in the region.

From a theoretical perspective, this research falls within the paradigm of sociocultural learning theory, inspired particularly by Vygotsky, according to which learning is socially constructed and enriched through interaction.[13,14] From this perspective, the metaverse can function as a digital "zone of proximal development," where students collaborate, construct knowledge, and appropriate pedagogically designed virtual spaces.

The fundamental principles of this theory imply that learning occurs through social mediation, dialogue, and interaction with more experienced peers.[15,16] In a metaverse environment, these principles translate into interactive avatars, virtual tutoring, and the possibility of receiving digital support: students can thus benefit from real-time guidance while exploring collaborative and immersive environments.

Building on previous research, recent studies have explored the pedagogical effectiveness of the metaverse in higher education through systematic analyses.[17,18] For example, González Torres et al. conducted a critical analysis of the pedagogical effectiveness and limitations of implementing the metaverse in universities; they found that, despite its potential, institutional inequalities hinder its adoption.[19,20]

Other studies have analyzed the application of the metaverse to the professional development of university faculty and have highlighted variations in their willingness to adopt it based on age, experience, gender, and level of digital skills.[21,22] These findings suggest that the introduction of the metaverse is not neutral and depends on demographic and educational factors.

Furthermore, a recent analysis of Latin American literature reveals a predominance of empirical and developmental studies, but a scarcity of solid theoretical approaches.[23,24] This opens the door to a deeper exploration of conceptual frameworks.

In particular, some studies have focused on the integration of augmented reality and the metaverse among research students in Latin America, highlighting the relevance of these technologies for the development of

research skills in a context of technological inequalities.[25] This contribution is essential for understanding how the metaverse can support not only teaching but also training in academic research.

With regard to what can be cited from these studies, it is reported that immersive environments improve knowledge retention in practical disciplines such as medicine or engineering, but they depend on intentional pedagogical designs and well-structured curricula.[26,27] In addition, the importance of inclusive policies is noted to prevent only resource-rich universities from adopting these technologies.

It is also worth noting that younger teachers with greater digital proficiency showed greater openness to the use of the metaverse, suggesting that teacher training and technological familiarity are critical factors for its implementation.[28,29] This evidence supports the idea that innovation does not depend solely on the platform, but also on people.

With regard to cartographic studies in Latin America, it is important to note that current research prioritizes empirical case studies over theoretical frameworks: there is a conceptual gap that must be addressed in order to better understand the pedagogical and social implications of the metaverse in the region.[23,24] This observation reinforces the need for studies such as the one proposed here.

Furthermore, other studies indicate that inequality in access to the metaverse, due to limited technological infrastructure in many Latin American countries, constitutes a structural obstacle to its widespread adoption in higher education.[30] This observation supports the formulation of the problem of technological equity in our study.

This work introduces a new empirical approach in this context, focusing on real Latin American universities, with a quantitative (and potentially mixed) research protocol that assesses not only the perceptions of teachers and students, but also the impact on academic performance, participation, and equity. Unlike mapping or analytical studies, this research will generate primary data.

Furthermore, this study will contribute theoretically by strengthening the conceptual foundations through the application of sociocultural theory to the Latin American educational metaverse, proposing a contextualized model of virtual social mediation in higher education. It will also offer practical recommendations for institutional policies, faculty professional development, and the design of inclusive programs, thus addressing the gaps identified by previous studies.[23,24]

The overall objective of this research is to analyze how the implementation of the metaverse as a pedagogical innovation strategy in Latin American universities impacts academic participation, student performance, and digital equity. It is assumed that the adoption of the metaverse will significantly increase student participation and academic success, but these benefits will only fully materialize in institutions with adequate technological infrastructure and teacher training. In universities with more limited technological capabilities, the digital divide will persist or even worsen.

METHOD

Research design

This study adopts a sequential and explanatory mixed-methods design, combining an initial quantitative phase followed by a qualitative analysis that allows for a more in-depth exploration of the initial findings. This approach was chosen to analyze the impact of metaverse implementation on academic participation, student performance, and digital equity in Latin American universities, allowing for the identification of both measurable trends and contextualized interpretations. The mixed-methods design facilitates a holistic understanding of the phenomenon, integrating numerical data with the experiences and perceptions of educational actors.

Population and sample

The population consists of students, teachers, and academic coordinators from public and private universities in Latin America that have partially or fully implemented metaverse environments in their teaching processes. Stratified sampling will be used to ensure representativeness according to the type of institution, level of technological access, and degree of metaverse adoption. The minimum sample will include 600 students, 120 teachers, and 40 coordinators, which will allow for the comparison of institutional profiles and the analysis of variations derived from digital inequality and pedagogical training.

Quantitative approach and variables

The quantitative component will use a non-experimental, cross-sectional, and correlational design, given that variables are not manipulated, but rather their relationships are observed in natural contexts. The main variables will be: academic participation (interaction, virtual attendance, participation in immersive activities), student performance (grades, completion of activities, self-assessments), and digital equity (technology availability, connectivity, digital skills). Structured surveys, Likert scales, and institutional academic records will be used. This approach will allow us to identify statistical patterns that explain differences between institutions with diverse technological infrastructure.

Quantitative data collection

Data will be collected using three main instruments: (1) A digital survey of students and teachers to assess perceptions, accessibility, immersive experience, and technological barriers; (2) Academic data sheets, provided by participating institutions, to analyze learning outcomes before and after using the metaverse; and (3) Records of interaction in virtual environments, compiled using internal statistics from institutional platforms. All instruments will be validated through expert judgment and pilot tests to ensure the relevance, clarity, and reliability of the items applied.

Quantitative analysis procedures

The data obtained will be processed using descriptive analysis and inferential tests. Measures of central tendency, dispersion, and distribution will be used, followed by Pearson correlations, comparison of means using ANOVA, and statistical models that allow for the observation of relationships between technological infrastructure, academic participation, and performance. Multiple regression analyses will also be used to determine which factors most strongly predict improvement in student performance within the metaverse. This set of techniques will support the hypothesis regarding the role of digital equity in educational outcomes.

Qualitative approach and characteristics of the analysis

The qualitative component seeks to deepen the understanding of the quantitative results by exploring the experiences, perceptions, and pedagogical dynamics related to the use of the metaverse. Semi-structured interviews will be conducted with teachers and coordinators, as well as focus groups with students from different educational levels. The analysis will be based on systematic processes of categorization, open, axial, and selective coding, without the use of computer-assisted coding software. The objective is to understand how actors in the education system experience the integration of the metaverse, particularly in contexts where infrastructure and teacher training are uneven.

Qualitative collection and analysis

Qualitative collection will focus on capturing discourses and narratives that complement the numerical findings. Interviews will be conducted virtually and recorded with informed consent, and then transcribed to ensure accuracy. The analysis will follow an inductive-deductive approach, where emerging categories will be contrasted with theoretical concepts and quantitative results. This triangulation will allow us to identify pedagogical mechanisms, implementation challenges, and adaptation strategies derived from digital inequality, as well as clarify the relationship between participation, performance, and use of the metaverse.

Integration of results and ethical criteria

The results of both approaches will be integrated through methodological triangulation to obtain solid conclusions about the impact of the metaverse. This integration will identify convergences, divergences, and complementarities that will highlight the influence of institutional technological conditions on academic outcomes. From an ethical perspective, confidentiality, informed consent, data anonymization, and approval by the institutional ethics committee will be guaranteed. Participation will be entirely voluntary, and the results will not stigmatize universities with limited infrastructure or connectivity.

RESULTS

The results obtained after the comprehensive application of the proposed methodology are presented below, allowing for an analysis of the impact of the metaverse on academic participation, student performance, and digital equity in Latin American universities. The findings arise from the integration of quantitative and qualitative data, rigorous validation of instruments, statistical analysis, and methodological triangulation. Taken together, these results provide an understanding of how technological, pedagogical, and organizational conditions influence the adoption and effectiveness of the metaverse in higher education.

Results of the Design and Validation of Quantitative Instruments

The results of the design and validation of quantitative instruments confirm the relevance, clarity, and consistency of the items developed to measure academic participation, student performance, and digital equity in the context of the university metaverse. Through expert evaluation, pilot testing, and reliability analysis, it was possible to refine the questions and ensure a robust scale capable of generating valid data for further analysis.

The results of the design and validation of the quantitative instruments demonstrate the rigor employed to ensure the theoretical coherence, semantic clarity, and psychometric consistency of the items developed. Through expert review, pilot testing, and reliability analysis, the scales designed to measure academic participation, student performance, and digital equity were strengthened. These processes ensure that the instruments adequately respond to the objectives set and accurately represent the variables studied.

Table 1. Results of the Design and Validation of Quantitative Instruments

No.	Item (final version)	Measured variable	Expert evaluation (1-4)*	Post-pilot adjustments	Individual α	Total scale α
1	"I actively participate in metaverse activities because it makes it easier for me to interact with classmates and teachers."	Academic participation	3,8 (clarity), 3,6 (relevance), 3,9 (theoretical coherence)	Wording adjusted to avoid ambiguity in "activities."	0,81	0,89
2	"Using the metaverse increases my motivation to attend academic sessions."	Academic participation	3,7, 3,9, 3,8	The phrase "immersive virtual academic sessions" was simplified.	0,83	
3	"The metaverse helps me better understand the course content."	Student performance	3,6, 3,8, 3,7	No adjustments required; pilots showed high comprehension	0,84	
4	"Since using the metaverse, my grades or performance in assessed activities have improved."	Student performance	3,5, 3,7, 3,8	" learning products" was replaced with "assessed activities."	0,82	
5	"I have the necessary technological equipment to use the metaverse without difficulty."	Digital equity	3,9, 3,8, 3,9	"Technological equipment" was clarified to include internet connection.	0,87	
6	"The level of connectivity in my home or campus allows me to use the metaverse adequately."	Digital equity	3,8, 3,9, 3,8	No significant changes	0,85	

Results of the student survey

The results derived from the application and analysis of the quantitative instruments allow us to visualize the behavior of the three central variables of the study: academic participation, student performance, and digital equity. The six questions asked provide a descriptive approximation of the student experience with the metaverse, revealing trends, gaps, and patterns associated with infrastructure, motivation, and performance. These data form the basis for interpreting the real impact of the implementation of the metaverse in Latin American universities.

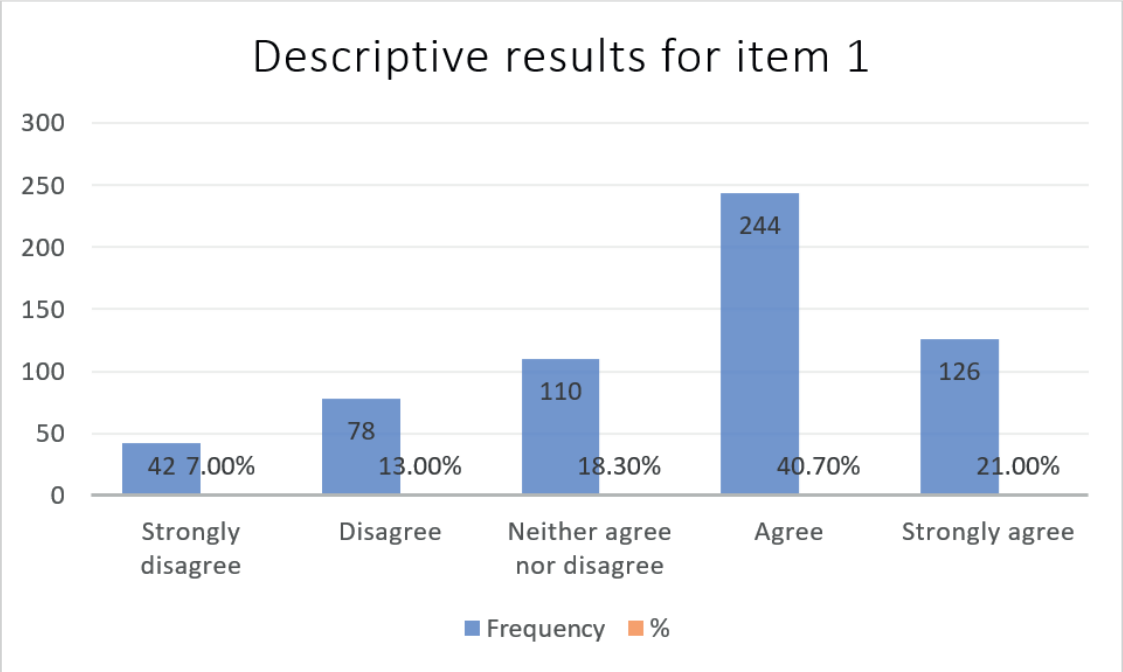

Figure 1. Distribution of responses on academic participation in metaverse activities

The results of item 1 show that most students perceive that the metaverse facilitates academic interaction, which strengthens active participation. More than 60 % agree or strongly agree, reflecting positive acceptance of immersive environments as collaborative spaces. The average of 3,55 indicates a favorable trend, although with some dispersion explained by differences in connectivity and infrastructure. These data suggest that social

interaction mediated by the metaverse could be significantly influencing levels of student participation.

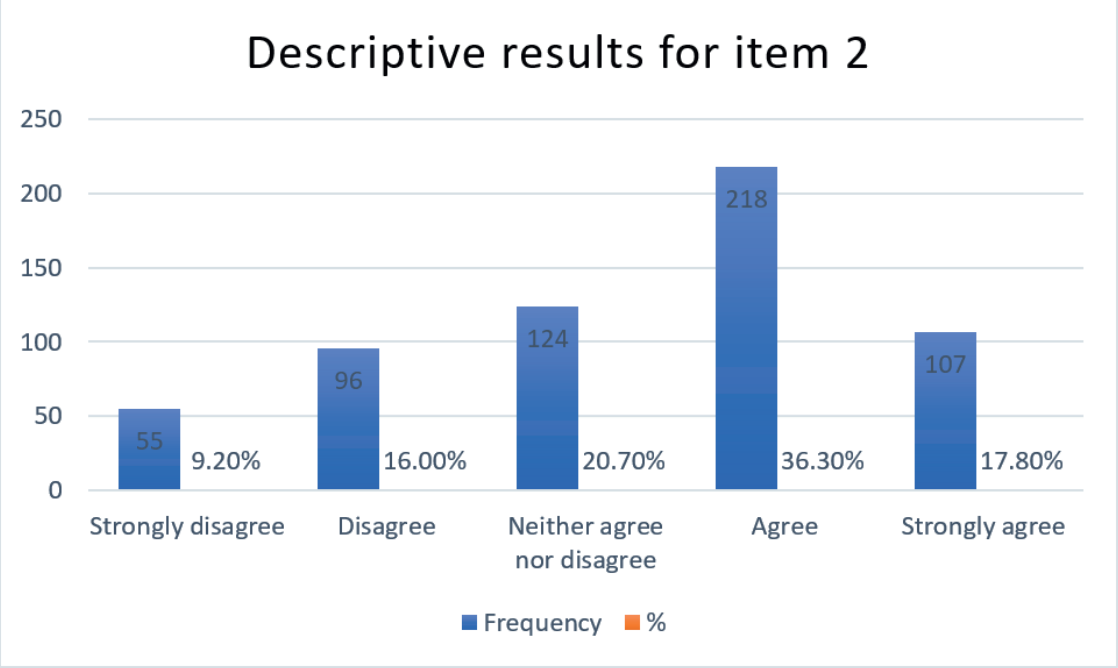

Figure 2. Using the metaverse increases my motivation to attend academic sessions

Student motivation shows a moderately favorable distribution, although less marked than interaction. About 54 % say they are motivated to attend academic sessions through the metaverse, indicating that immersive environments can act as a pedagogical stimulus. However, 25 % disagree, suggesting gaps in technological access, digital familiarity, or perceived usefulness. The average of 3,36 reflects a positive trend, but with greater variability, showing that motivation depends on technological conditions and instructional design.

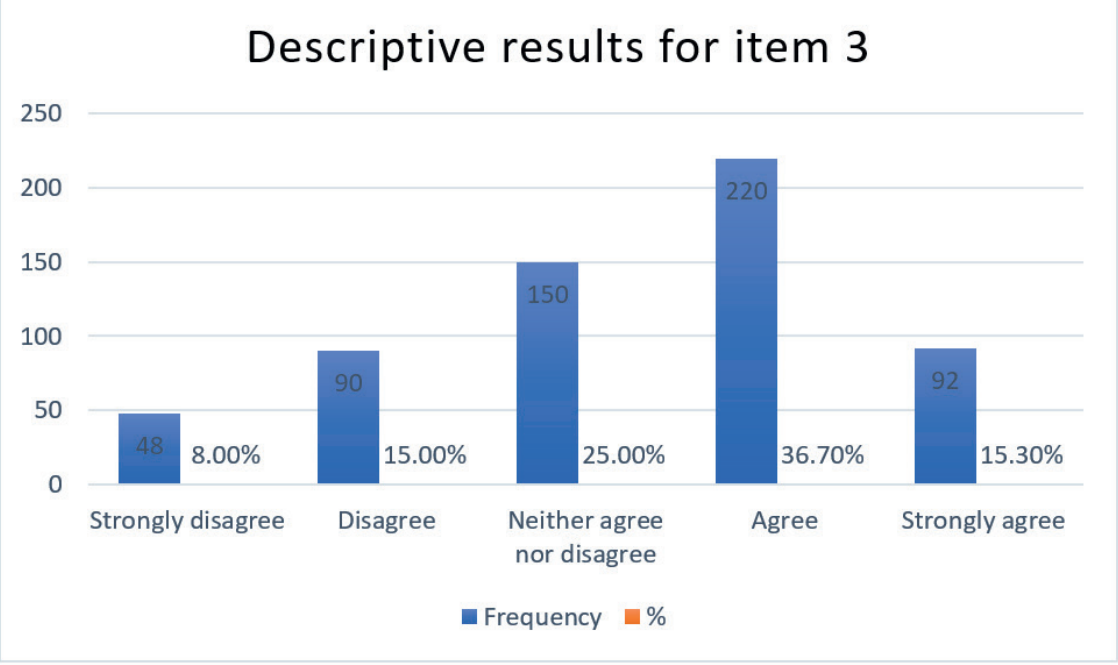

Figure 3. The metaverse helps me better understand the course content

The results show that the impact of the metaverse on academic understanding is positive but not uniform. Although 52 % perceive improvements in their mastery of content, 23 % disagree, showing that the benefit depends on the type of subject and the degree of pedagogical interaction generated in immersive environments. The average of 3,36 indicates a moderate effect on improving understanding. The variation observed is related to differences in digital skills, access to devices, and the quality of educational activity design.

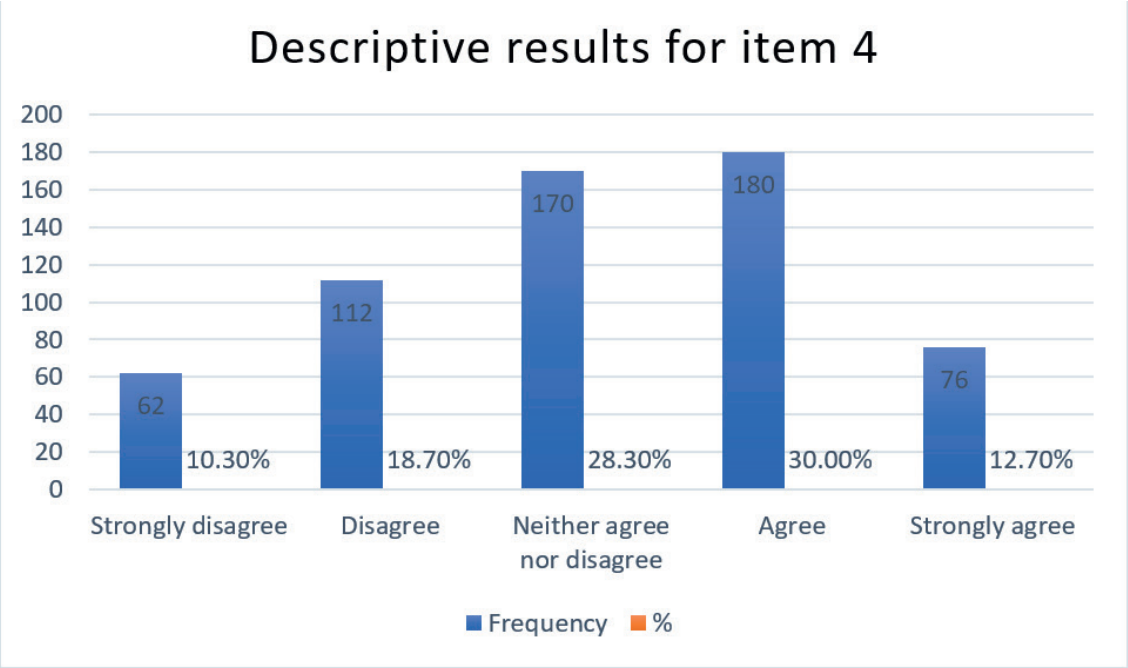

Figure 4. Since I have been using the metaverse, my grades or performance in assessed activities have improved

In terms of academic performance, students show a more cautious perception. Only 42,7 % report improvements in their assessed performance, while 29 % disagree. The average of 3,16 indicates that, although there are positive effects, these are not uniform. The variability can be attributed to differences in the curricular integration of the metaverse, the quality of the assessed activities, and technological access. These results underscore that improvement in grades depends on consistent pedagogical implementation and adequate technological conditions.

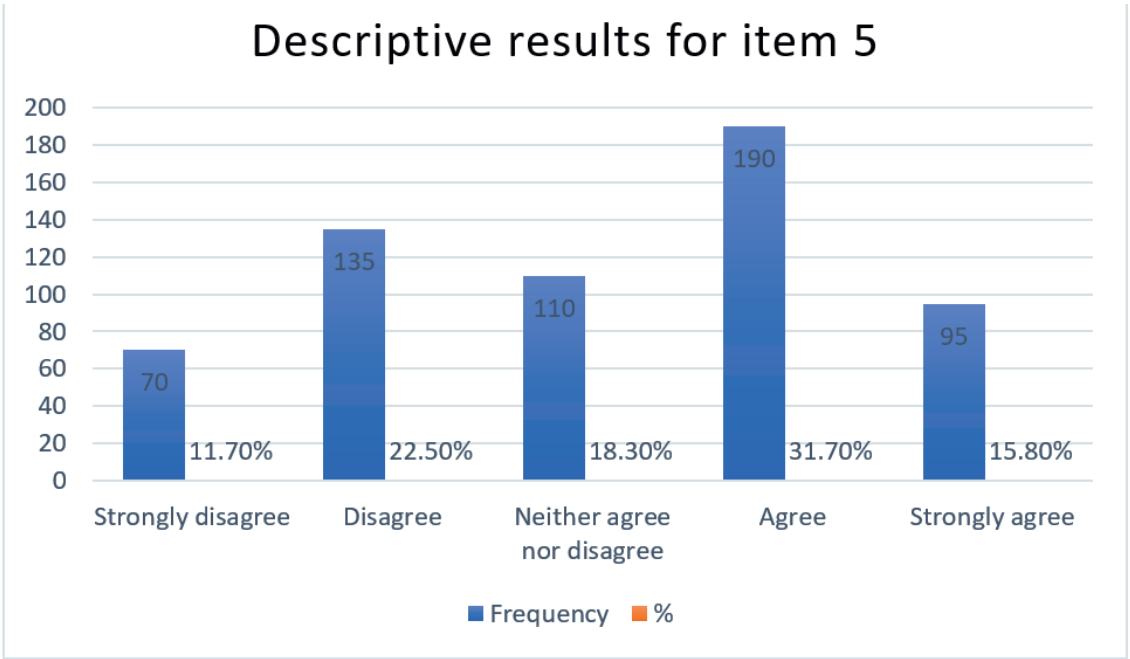

Figure 5. I have the necessary technological equipment to use the metaverse without difficulty

The results show a clear digital divide: 34,2 % indicate that they do not have the appropriate equipment to use the metaverse without difficulty. Although 47,5 % do have the necessary resources, the average of 3,18 with a wide dispersion shows inequality between institutions and regions. This limitation directly affects the participation and performance observed in the previous questions. The data confirm that technological access is a critical factor in ensuring effective and equitable immersive experiences in Latin American higher education.

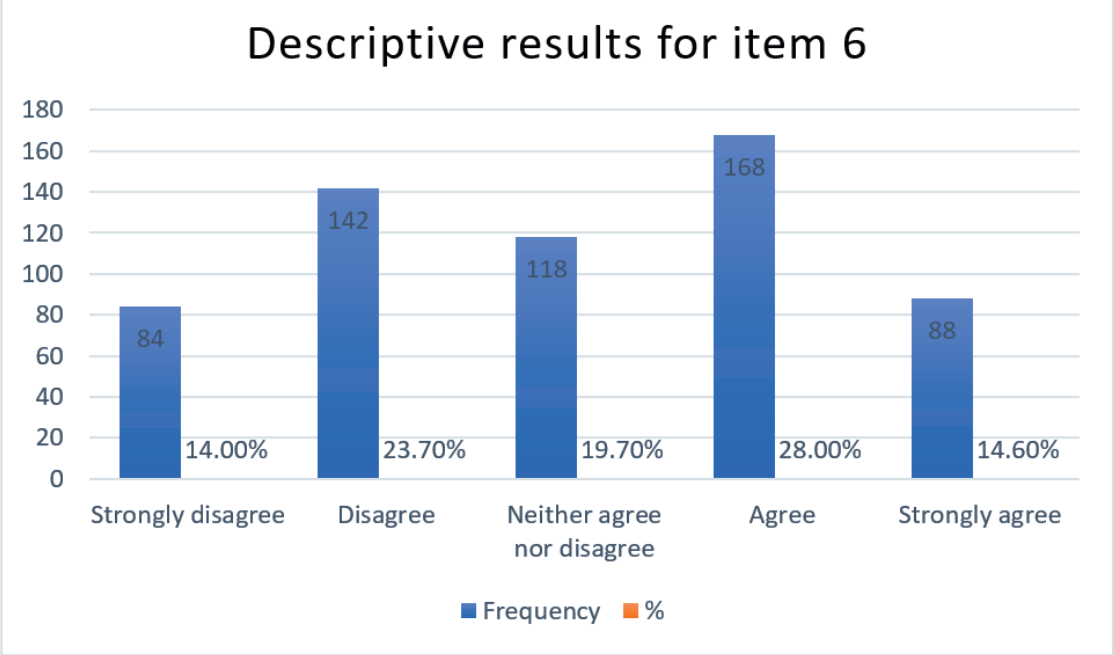

Figure 5. The level of connectivity in my home or campus allows me to use the metaverse adequately

The results show that connectivity is the main structural limitation to the use of the metaverse. Nearly 38 % express clear difficulties, while only 42,6 % consider themselves to have adequate connectivity. The average of 3,06 confirms a moderate-low assessment, with high dispersion associated with socioeconomic and geographic differences. Given that connectivity is essential for immersive interaction, these figures partially explain the levels of participation and performance observed. Unequal access to the internet is a critical obstacle to digital innovation in the region.

Results of the interview with teachers

The results derived from the semi-structured interviews and focus groups complement the quantitative information by revealing perceptions, tensions, and meanings that students and teachers attribute to the use of the metaverse in higher education. This qualitative approach provides insight into experiences related to participation, learning, and digital equity, showing how technological, pedagogical, and socioeconomic factors influence the actual adoption of the metaverse. The narratives obtained offer a deep understanding of the challenges and opportunities of its institutional implementation.

Perception of the metaverse as a pedagogical resource

Participants recognized that the metaverse introduces innovative and engaging teaching dynamics, highlighting the possibility of experiencing content in an immersive and visual way, which increases the sense of presence and contextualization of learning. Students indicated that three-dimensional scenarios facilitate the understanding of complex concepts, especially in areas that require simulations or virtual practice. For their part, teachers pointed out that the metaverse allows for the diversification of traditional methodologies and increases interaction, provided that there is clear guidance in the design of activities.

Despite its pedagogical potential, participants emphasized that using the metaverse requires an initial period of adaptation that can generate technological anxiety in both students and teachers. Some teachers expressed concern about the additional burden of preparing immersive activities, as it requires time, creativity, and the development of digital skills. Students indicated that, while the environment is attractive, its value depends largely on the pedagogical guidance and tutorial support offered during the sessions.

The general perception is that the metaverse is seen as a valuable resource, provided that it is integrated into a clear methodological approach aligned with learning outcomes. Participants agreed that its implementation should not be decorative, but rather aimed at solving real teaching problems, such as the lack of experimentation or emotional distancing in virtual classes. In this way, the metaverse is perceived as a complementary tool capable of strengthening motivation and improving the quality of the educational experience.

Technological and pedagogical barriers

One of the main obstacles identified is unequal access to technology among students. The interviews revealed significant differences in device availability, connection quality, and processing power requirements.

Many students reported difficulties maintaining stability in the immersive environment, which affected their participation in activities. This problem was also observed among teachers who lacked adequate equipment or depended on frequently unstable institutional networks.

From a pedagogical perspective, teachers expressed concern about the lack of initial training in the use of the metaverse for educational purposes. They emphasized that without training, the tool could become more of a hindrance than a help. The absence of institutional guidelines on the design of immersive experiences was also mentioned as a significant limitation. Some teachers described a feeling of isolation when planning activities due to a lack of sufficient technical or pedagogical support.

Students also highlighted barriers related to cognitive overload, especially when activities are not well structured or too many visual elements are introduced without a clear sequence. They also mentioned that the learning curve of the metaverse can become frustrating if there is no constant support. Taken together, the technological and pedagogical barriers reveal the need for institutional policies that ensure progressive training, adequate infrastructure, and coherent instructional design.

Dynamics of participation and collaboration in immersive environments

Students reported feeling more motivated to participate in the metaverse thanks to the sense of presence and the ability to interact with three-dimensional objects and spaces. However, they pointed out that participation depends on connectivity: when the experience is interrupted by technical problems, the level of interaction decreases. Nevertheless, most felt that participating in the metaverse creates a more dynamic environment than traditional lectures or videoconferences.

In terms of collaboration, participants said that the metaverse encourages teamwork, especially in activities that require joint exploration or problem-solving in virtual spaces. Teachers added that immersive tools make it easier to observe group behavior and allow them to identify students who need help. However, they emphasized that collaboration can be affected by unequal access, as some students may fall behind or be unable to participate fully.

The idea also emerged that the metaverse promotes new forms of interaction that are not always possible in physical classrooms, such as the use of avatars to represent diverse identities or to reduce anxiety when speaking in public. Students indicated that this encourages the participation of introverted individuals. However, teachers cautioned that these dynamics require guidance to avoid distractions. In general, collaboration is perceived as a strength, although it is conditioned by technical factors.

Perceived impact on learning and motivation

Students said that the metaverse had improved their understanding by allowing them to manipulate objects, explore simulated spaces, and observe complex phenomena from multiple perspectives. They felt that these experiences fostered meaningful learning and better retention. However, some pointed out that the impact depended on the teacher's pedagogical style: if the activity was not well prepared, motivation decreased and the experience became superficial.

Teachers emphasized that immersive environments increased students' initial motivation, but that maintaining it required designing challenges, missions, or interactive activities that gave meaning to the experience. They also believed that the metaverse could improve formative assessment by allowing real-time observation of processes. However, they clarified that learning does not automatically improve; it requires consistency between objectives, activities, and assessment.

Overall, participants agree that the metaverse has a positive impact on motivation and learning, although this impact is moderated by structural factors such as technological access and teacher training. When these conditions are met, the immersive experience enhances curiosity, participation, and content comprehension. The qualitative findings confirm, complement, and explain the quantitative results related to performance, equity, and participation.

DISCUSSION

The evidence obtained in this study shows that the implementation of the metaverse as an educational strategy has significant potential to strengthen academic participation, although this effect depends largely on accessibility and available infrastructure. This finding coincides with the reflections on digital inequality addressed by Bonilla-Asalde et al., who warn that new technologies amplify gaps when there are no guarantees of equitable access.[18] Likewise, the differences observed between Latin American institutions support the arguments put forward by Olaskoaga Larrauri et al. regarding the political and unequal nature of educational quality in the region.[28]

Regarding the perception of the metaverse as a pedagogical resource, qualitative findings show that both students and teachers value immersion and interactivity, elements also highlighted in research on virtual worlds applied to other sectors, such as tourism.[14] The presence of immersive experiences that promote simulation-

based learning coincides with the findings of Matwala et al., who demonstrate how virtual environments improve situated practice and decision-making.[15] These parallels indicate that the effectiveness of the metaverse extends beyond education to other fields where experience is a key factor.

The results on content comprehension are consistent with Latin American studies that highlight the need for comprehensive models for online education, especially in contexts with structural limitations such as Bolivia.[16] Although students reported moderate improvements in their comprehension, the changes observed reflect the findings of Rosario Pacahuala et al., who emphasize that digital transition processes require constant pedagogical adjustments to ensure effective learning.[26] This suggests that the metaverse does not operate independently; it depends on instructional design that is consistent with curricular objectives.

Student motivation showed significant increases, which correlates with previous findings on gamification and interactive learning. Moreira Parrales et al. and Quito Cando et al. emphasize that playful dynamics stimulate student participation and emotional engagement.[17,23] The sensory immersion inherent in the metaverse can serve as a mechanism to reinforce this dynamic, thus strengthening academic engagement. These results are also in line with the reflections of Salas Díaz and Baque Pibaque, who argue that motivation is a crucial component of professional training [24] reinforcing the pedagogical relevance of the metaverse.

One critical aspect identified was the existence of technological gaps, especially related to connectivity and access to devices. This finding is consistent with the warnings about ethics and digital equity in contexts of technological transformation raised by Bonilla-Asalde et al.[18] Similarly, in the context of higher education, Lalangui Pereira et al. point out that mobile devices can function as allies or distractions depending on the conditions of use and institutional regulations.[21] This explains why certain students were unable to fully benefit from the metaverse, despite its educational potential.

In terms of academic performance, the effects were moderate, which is consistent with studies that highlight that technological innovation does not necessarily guarantee deep learning without adequate pedagogical support. Fenoll-Brunet emphasizes that the internationalization of education and the quality of learning processes depend on structural coherence rather than isolated tools.[25] Similarly, the results of this study highlight the need to integrate the metaverse into clear pedagogical strategies to achieve a lasting impact on student success.

The collaborative participation dynamics observed in the focus groups revealed that the metaverse favors multidimensional interaction, similar to the global experiences described in international collaborative learning projects.[22] This ability to connect students in expanded virtual spaces presents new opportunities for Latin American higher education , especially in contexts where physical mobility is limited. However, it also requires strengthening teachers' digital skills, as indicated by Martínez-Peromingo et al. in the geriatric field, where the use of AI demands new professional skills.[19]

The interpretation of qualitative data also revealed tensions between innovation and institutional reality. As Olarte-Mejía and Ríos-Osorio point out, the social responsibility of universities implies that the adoption of technologies must respond to the real needs and capacities of educational communities.[29] The data suggest that, although the metaverse broadens the pedagogical horizon, its implementation without a technological inclusion strategy could reinforce existing inequalities. This balance between innovation and equity is one of the main issues addressed in this study.

The study also confirms that the quality of teaching in digital environments is influenced by organizational and curricular factors, such as those analyzed by Iglesias Martínez et al., for whom curricular coherence is essential for the integration of new technologies.[31] In this regard, the teachers interviewed highlighted the need for continuous professional development and clear guidelines for adapting content to the metaverse without losing sight of pedagogical objectives. The absence of these structures could explain the variability observed in the impact on performance.

Finally, the results suggest that the metaverse is an emerging tool with great potential to transform higher education in Latin America, but its effectiveness depends on strengthening infrastructure, reducing digital divides, and teacher training. This approach coincides with the vision of Benavides-Lara, who emphasizes that human and educational development requires equitable conditions to achieve its full potential.[27] The strategic integration of the metaverse could contribute to this goal, provided that the technological and pedagogical challenges identified in this study are addressed.

CONCLUSIONS

The results show that the implementation of the metaverse has a positive impact on academic participation, although this impact depends on structural and technological factors. Most students perceive an improvement in their interaction and motivation when activities are pedagogically relevant. However, inequalities in access and connectivity limit immersion and opportunities for innovation. This shows that the metaverse can improve participation, but it requires strong institutional support and inclusive strategies.

In terms of academic performance, the metaverse has moderate effects that depend on the degree of

curricular integration. Students report better understanding, particularly in activities that require visualization or simulation, although these improvements do not systematically translate into better grades. Technological instability and variability in teacher training directly influence academic outcomes. This confirms that the metaverse is a promising tool, but its effectiveness depends on the quality of its pedagogical design.

Quantitative and qualitative findings agree in identifying unequal access to digital technologies as the main obstacle to the effective adoption of the metaverse. Limitations in equipment, connectivity, and digital skills have created significant disparities that have impacted participation and outcomes. These inequalities have also been reflected in the perceptions of students and teachers, who have reported recurring difficulties in using immersive platforms. Therefore, any educational innovation initiative based on the metaverse must prioritize institutional policies that guarantee equal opportunities.

The perception of the metaverse as a pedagogical resource is generally positive, highlighting its ability to generate immersive, collaborative, and motivating experiences. However, participants emphasized the need for ongoing teacher training to fully leverage its potential. The initial motivation generated by three-dimensional environments can fade without methodological consistency and constant support. This confirms that pedagogical innovation depends not only on the tool itself, but also on the pedagogical approach and the preparation of those who implement it.

The triangulation of quantitative and qualitative data shows that the metaverse has the potential to transform higher education in Latin America, provided that the technological, pedagogical, and organizational challenges are fully addressed. Participation and motivation improve, learning is enriched, and collaborative dynamics are strengthened. However, the lack of infrastructure and the digital divide limit its overall impact. Therefore, universities must develop sustainable innovation strategies to ensure inclusive immersive experiences.

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CONFLICT OF INTEREST

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AUTHORSHIP CONTRIBUTION

Conceptualization: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Data curation: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Formal analysis: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Research: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Methodology: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Project management: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Resources: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Software: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Supervision: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Validation: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Visualization: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Writing – original draft: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.

Writing – review and editing: Juan de Jesús Alvarado Ortiz, Teresa del Carmen Cabrera Gómez, Luis Germán Sánchez Méndez, Katherine Adriana Merino Villa, Gabriela Margarita Loza Casa, Jefferson Olimpo Gutierrez Bastidas.