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ORIGINAL

Integration of the metaverse into university education in rural areas: Challenges and opportunities

Integración del metaverso en la educación universitaria en zonas rurales: Retos y oportunidades

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ABSTRACT

The study was conducted in response to the need to integrate immersive technologies into university education in rural areas, where digital gaps limited access to quality learning experiences. The main objective was to analyze the integration of the metaverse into rural higher education, identifying the technological, pedagogical, and socioeconomic challenges associated with its implementation. The research adopted a mixed empirical approach, combining a structured questionnaire with six Likert-type items applied to 120 students and semi-structured interviews conducted with 20 faculty members from three rural universities selected through purposive sampling. Results showed that more than half of the students had the necessary technological resources and expressed positive attitudes toward immersive learning. However, deficiencies in infrastructure, connectivity, and teacher training were identified. The interviews revealed that although professors perceived the metaverse as an innovative tool, they considered institutional support and ongoing training essential. In conclusion, integrating the metaverse into rural university education represented a significant opportunity to improve equity, motivation, and educational quality, provided that technological sustainability and contextual relevance were ensured.

Keywords: Metaverse; Higher Education; Rural Areas; Educational Innovation.

RESUMEN

El estudio se desarrolló ante la necesidad de incorporar tecnologías inmersivas en la educación universitaria de zonas rurales, donde las brechas digitales limitaban el acceso a experiencias formativas de calidad. El objetivo general fue analizar la integración del metaverso en la educación universitaria rural, identificando los retos tecnológicos, pedagógicos y socioeconómicos asociados a su implementación. La investigación adoptó un enfoque mixto de tipo empírico, combinando un cuestionario estructurado con seis ítems tipo Likert aplicado a 120 estudiantes y entrevistas semiestructuradas realizadas a 20 docentes de tres universidades rurales seleccionadas mediante muestreo intencional. Los resultados mostraron que más de la mitad de los estudiantes disponía de los recursos tecnológicos necesarios y manifestaba actitudes positivas hacia el aprendizaje inmersivo. Sin embargo, se evidenciaron carencias en infraestructura, conectividad y formación docente. Las entrevistas revelaron que, aunque los profesores percibieron al metaverso como una herramienta innovadora, consideraron imprescindible el acompañamiento institucional y la capacitación continua. En conclusión, la integración del metaverso en la educación universitaria rural representó una oportunidad significativa para mejorar la equidad, la motivación y la calidad educativa, siempre que se

garantizara sostenibilidad tecnológica y pertinencia contextual.

Palabras clave: Metaverso; Educación Universitaria; Zonas Rurales; Innovación Educativa.

INTRODUCTION

The objective of this research is to analyze the integration of the metaverse into rural higher education, identifying its technological, pedagogical, and socioeconomic challenges. This study addresses the tension between the potential of immersive environments and the material constraints that characterize many rural contexts. Therefore, it proposes an empirical program that combines field evidence with a critical review of recent literature, seeking to ensure that the integration of extensive technologies is consistent with the principles of equity and cultural relevance. This approach emphasizes the need for contextualized and applied evidence.

The research will explore the opportunities offered by the metaverse to improve access, quality, and relevance of education, especially in contexts with infrastructural limitations.[1,2] Potential benefits described include virtual laboratories, professional simulations, and inter-university collaborative spaces capable of overcoming physical limitations. However, technological potential requires rigorous evaluation: what works, for whom, and under what conditions. Consequently, the research will propose indicators of effectiveness, acceptability, and sustainability in rural contexts with limited resources and sociocultural diversity.

We start from the premise that immersive technologies can transform teaching and learning practices through simulations, remote collaboration, and contextual knowledge representation.[3,4] The central hypothesis suggests that, under adequate conditions of access and instructional design, the metaverse can improve procedural understanding and practical transfer. However, educational transformation depends as much on technology as it does on pedagogical designs that promote meaningful interaction, authentic assessment, and integration with local knowledge in rural contexts.

Nevertheless, there are concrete barriers: unstable connectivity, device costs, insufficient teacher training, and cultural resistance that hinder sustainable adoption. These barriers not only limit technical access but also affect pedagogical and community appropriation. Empirical research should document the extent of these obstacles, distinguishing between transitory problems (e.g., initial provision of equipment) and structural challenges (network infrastructure, maintenance, and educational governance) that require collaborative public policies and financing models.[5]

Recent studies have demonstrated the positive pedagogical impact of virtual environments in higher education, but emphasize the need to contextualize interventions according to rural realities.[6] Favorable results in urban environments or specialized laboratories are not always replicated in dispersed environments with limited resources. Therefore, research should prioritize evaluations in rural contexts, adopting mixed methods that record improvements in specific learning outcomes, as well as effects on inclusion, retention, and digital skills.[7]

Rural communities have unique characteristics, such as geographical dispersion and limited resources, which require flexible solutions and public policies aimed at digital inclusion.[8,9,10,11] Technological interventions must be integrated with territorial development initiatives, taking advantage of local infrastructure (community centers, mobile classrooms) and hybrid strategies that combine face-to-face and virtual experiences. Intersectoral collaboration is essential to avoid fragmented projects and ensure educational and technical continuity.

Beyond infrastructure, digital equity requires digital skills, adequate teaching resources, and sustainable financing models that enable scalability and maintenance.[12] Simply distributing devices is not enough: it is necessary to train teachers, produce culturally relevant content, and provide local technical support. Sustainability depends on institutional frameworks that integrate maintenance, updates, and ongoing evaluation to prevent technology from becoming a temporary project with no lasting impact on the quality of education.

From the teachers' perspective, successful integration requires continuous training, participatory curriculum design, and technical support to adapt methodologies to immersive platforms.[13,14,15,16] Training must go beyond the purely instrumental and promote specific pedagogical skills for teaching in virtual environments: the design of interactive activities, assessment in immersive scenarios, and the management of learning communities. Participatory design with rural teachers promotes contextual relevance and ownership, reducing resistance and increasing the effectiveness of initiatives.

Students living in rural areas can benefit from immersive experiences that replicate professional practices and complex environments that are difficult to reproduce in their local context.[7] Laboratory simulations, virtual clinical practices, and immersive visits to cultural heritage sites expand learning opportunities and link university education to local needs. However, it is essential that these experiences consider accessibility, low

latency, and adaptability to different device capabilities, thus ensuring technological inclusion.

Partnerships between universities, governments, the private sector, and community organizations are emerging as a key strategy for addressing gaps and ensuring local ownership.[15] These consortia allow for the pooling of resources, technical expertise, and local knowledge, facilitating models of co-investment and shared responsibility. In addition, collaborative governance contributes to the design of data protection protocols, support mechanisms, and evaluation criteria aligned with the social and educational needs of rural communities.

The analysis must consider the ethical and security aspects of virtual environments, such as data privacy, harassment, and inappropriate cultural representations.[1] Immersive platforms generate sensitive data and experiences that can compromise the integrity of students and communities. The research will explore digital ethics frameworks, protection policies, and participation mechanisms that allow rural communities to influence how their realities are represented and managed in the metaverse.

Assessing costs and economic models is essential to designing interventions that do not exacerbate inequalities or rely solely on temporary funding.[13] The study will analyze alternatives: shared infrastructure, mobile classrooms, university subscription models, and public-private partnerships with social responsibility clauses. Financial viability must consider initial investment, management, technological upgrades, and ongoing training to ensure continuity and scalability in rural contexts.

Empirical research requires mixed methods that integrate quantitative indicators of access and performance with qualitative analyses of perceptions, uses, and resistance.[9] Surveys, performance tests, in-depth interviews, and educational ethnographies are proposed to capture contextual complexity. This approach will identify not only average effects but also internal heterogeneities: student subgroups, differences by field of study, and variations based on the level of institutional support.

Likewise, it is proposed to study pilot cases to identify practices and lessons that can be replicated in regional and national policies.[10] Pilot projects should be designed with process and outcome indicators, feedback mechanisms, and expansion strategies. Documenting experiences in different rural areas will facilitate the development of operational guidelines and educational policy frameworks that integrate lessons on technology, pedagogy, and governance.

Finally, this work seeks to provide evidence to guide institutional decisions, training proposals, and regulatory frameworks that promote inclusion in the metaverse.[5] The research aims to generate concrete recommendations for rural universities and policymakers, integrating technical, pedagogical, and ethical considerations. These recommendations will be aimed at maximizing educational opportunities without reproducing existing gaps, promoting a design approach focused on community and equity.

A review of the international literature reveals progress and, at the same time, raises concerns about the risk of reproducing digital inequalities in the absence of compensatory measures.[14] It is essential that metaverse initiatives integrate universal access and complementary training strategies to prevent emerging technologies from benefiting only those who already have digital privileges. The research will evaluate effective and sustainable compensatory measures in rural contexts.

Contextualizing the metaverse involves leveraging local knowledge, designing relevant content, and ensuring community participation in the adoption process.[17] Projects based on external solutions that lack local legitimacy tend to have low adoption rates. Therefore, participatory and co-creation processes are promoted,[8,15] integrating local actors into curriculum design, content production, and technological governance, thus strengthening the relevance and legitimacy of initiatives.

This study seeks to combine theoretical findings with field evidence, proposing practical recommendations for school administrators, teachers, and policymakers. It will consider concerns about safety and gender in virtual environments, along with best practices for digital inclusion, to formulate proposals that reduce risks and maximize benefits. The goal is to offer realistic action plans tailored to the capacities and priorities of rural communities.

This work will also showcase examples of digital inclusion programs and best practices that can guide the implementation of the metaverse in rural areas. It will analyze experiences from mobile classrooms, community centers, and regional partnerships that have demonstrated an impact on digital literacy and citizen participation, identifying critical success factors that can be applied to the design of metaverse initiatives in higher education.

METHOD

Research approach

The study was designed with a mixed (quantitative and qualitative) approach to comprehensively analyze the integration of the metaverse in higher education in rural areas. This approach combines statistical data on access to and use of technology with in-depth interpretations of perceptions, experiences, and cultural resistance prior to the use of immersive environments in higher education. Methodological complementarity was a priority in order to achieve a holistic understanding of the educational phenomenon.

Type and design of the study

The research is based on a non-experimental, cross-sectional, descriptive-correlational design. It seeks to identify relationships between variables such as technological infrastructure, teacher training, digital accessibility, educational participation, and perceptions about the pedagogical use of the metaverse. The empirical component included direct observations and structural and semi-structural h al analyses, applied during a single academic period. This design allowed for the simultaneous analysis of the reasons and opportunities for adopting the metaverse in rural contexts.

Population and sample

The population consisted of public and private universities located in rural or semi-urban areas, offering bachelor's degree and vocational training programs. Three institutions were selected through purposive sampling, considering: (a) rural location, (b) availability of basic digital infrastructure, and (c) institutional willingness to participate in studies on educational innovation. The sample included 120 students and 20 teachers, who participated voluntarily. The institutional diversity allowed for a comparison of experiences between contexts with different levels of technological development.

Data collection techniques and instruments

For the quantitative component, a structured questionnaire with six Likert-type items (scale of 1 to 5) was used, validated by experts in educational innovation and technology. The instrument measured four dimensions: technological accessibility, teacher digital competence, pedagogical interaction in the metaverse, and perception of educational impact.

The qualitative component was based on semi-structured interviews with teachers and focus groups with students to explore attitudes, barriers, and expectations regarding the use of the metaverse in their academic environments. All sessions were recorded with prior consent and transcribed for thematic analysis.

Data collection procedure

Data collection was carried out over one academic semester. In the first phase, the questionnaire was administered to students and teachers at the selected universities. Subsequently, interviews and focus groups were conducted, with an average duration of 60 minutes. The sessions were conducted both in person (in equipped classrooms) and virtually (via videoconferencing platforms), ensuring the inclusive participation of rural communities with limited connectivity. Asynchronous communication strategies were used to overcome difficulties in accessing the internet.

Data analysis

Quantitative data were processed using SPSS version 26 software, applying descriptive statistics (frequencies, means, standard deviations) and Pearson's correlation analysis to identify relationships between key variables.

Qualitative data were analyzed using thematic content analysis, following the phases of open coding, axial categorization, and conceptual interpretation. This process allowed us to identify narrative patterns regarding perceptions, benefits, and resistance surrounding the use of the metaverse. The results of both approaches were integrated using methodological triangulation to reinforce the validity of the study.

Ethical considerations

The study complied with the ethical principles established by the Declaration of Helsinki and university regulations on educational research. All participants signed an informed consent form, guaranteeing confidentiality and anonymity. The collection of sensitive data was avoided, and it was ensured that participation did not involve any academic or personal risk. In addition, the results will be shared with the collaborating institutions, promoting the social return of the knowledge generated.

Study limitations

Among the main limitations identified are irregular connectivity in rural areas, which affected the application of online instruments, and the small sample size, which limits the generalizability of the results. Likewise, the use of self-reports could incorporate social desirability biases. However, methodological triangulation and institutional diversity strengthened the validity of the findings and provide a solid basis for future longitudinal and comparative research on the educational metaverse.

RESULTS

This section presents the results obtained from the application of data collection instruments to 120 students and 20 teachers from universities located in rural areas. The quantitative analysis focuses on student perceptions of technological availability, teaching skills, pedagogical impact, and sustainability of the metaverse in higher

education. The results reflect general trends in acceptance, existing technical limitations, and opportunities for improvement that would strengthen inclusion and educational equity through immersive environments.

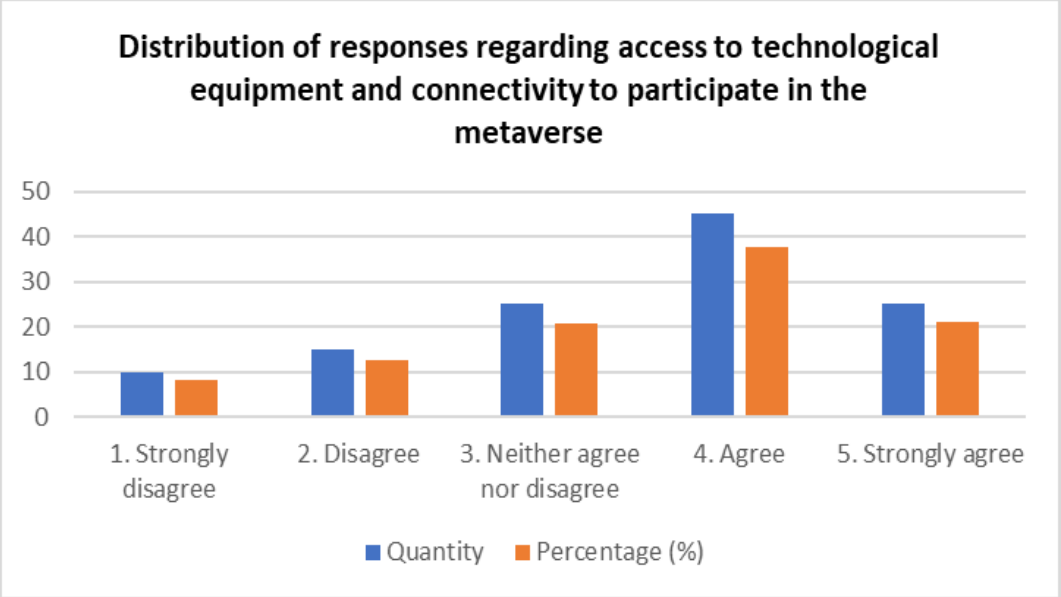

Figure 1. Do you have the necessary technological equipment and connectivity to participate effectively in educational activities developed in the metaverse?

The results show that 58,4 % of students (levels 4 and 5) have the necessary equipment and connectivity to participate in educational experiences in the metaverse. However, 20,8 % express some level of disagreement, indicating the persistence of technological gaps. This difference shows that, although there is a favorable foundation, the digital infrastructure in rural areas still needs to be strengthened to ensure the equitable participation of all students in immersive environments.

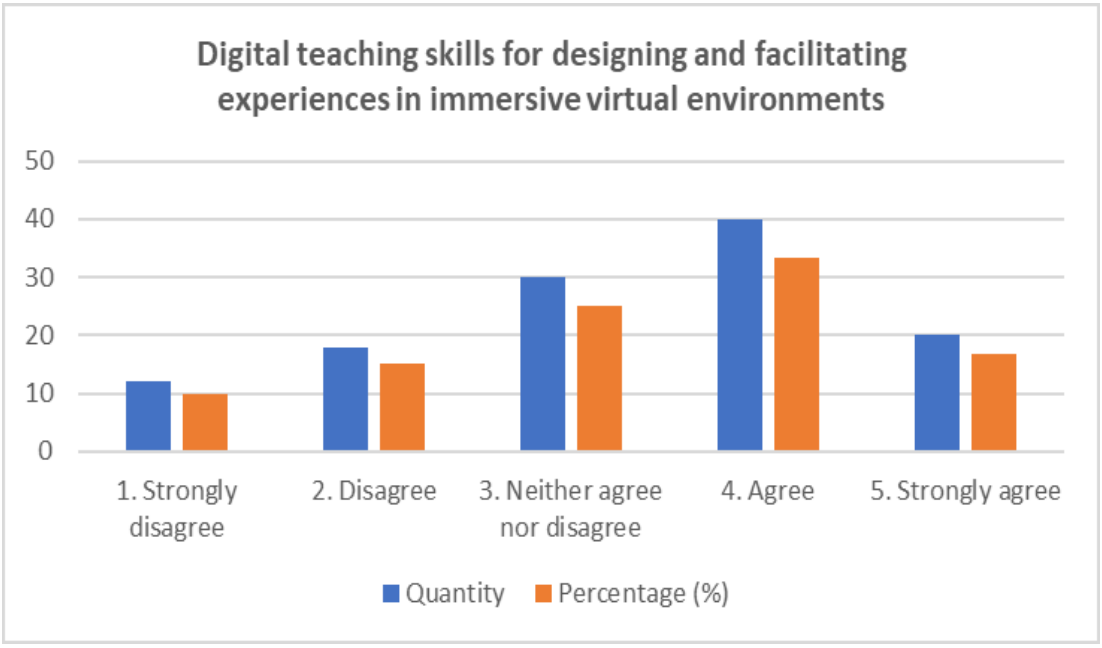

Figure 2. Do teachers at your institution demonstrate sufficient digital skills to design and facilitate learning experiences in immersive virtual environments?

Fifty percent of respondents believe that teachers have the necessary digital skills (levels 4 and 5), while 25 % remain neutral. This suggests that institutional training efforts are in place, but there is still room to strengthen teacher preparation in metaverse tools. Rural institutions should implement continuing education programs that promote technical and pedagogical mastery of immersive environments, ensuring innovative and contextualized learning experiences.

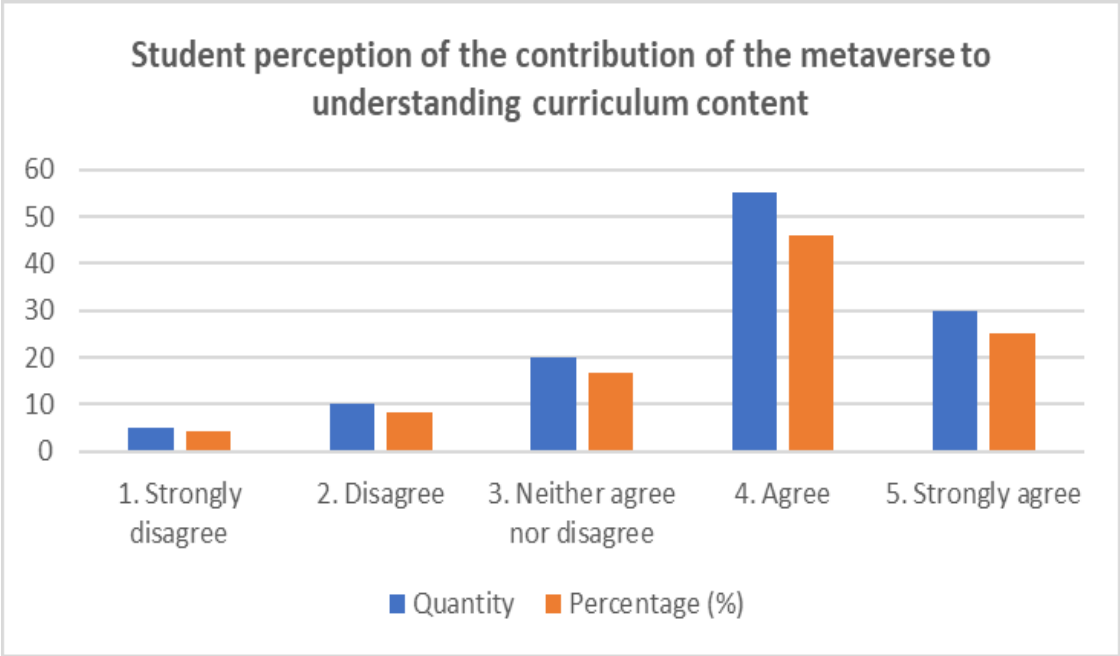

Figure 3. Do you believe that academic activities incorporating the metaverse contribute to improving understanding of curriculum content?

70,8 % of students (levels 4 and 5) perceive that metaverse-based activities improve content comprehension. This demonstrates the pedagogical potential of immersive environments to facilitate conceptual and practical assimilation, especially in technical or experimental fields of study. However, the existence of 12,5 % disagreement indicates that their effectiveness may depend on the didactic design and technological familiarity of users, rather than on the tool itself.

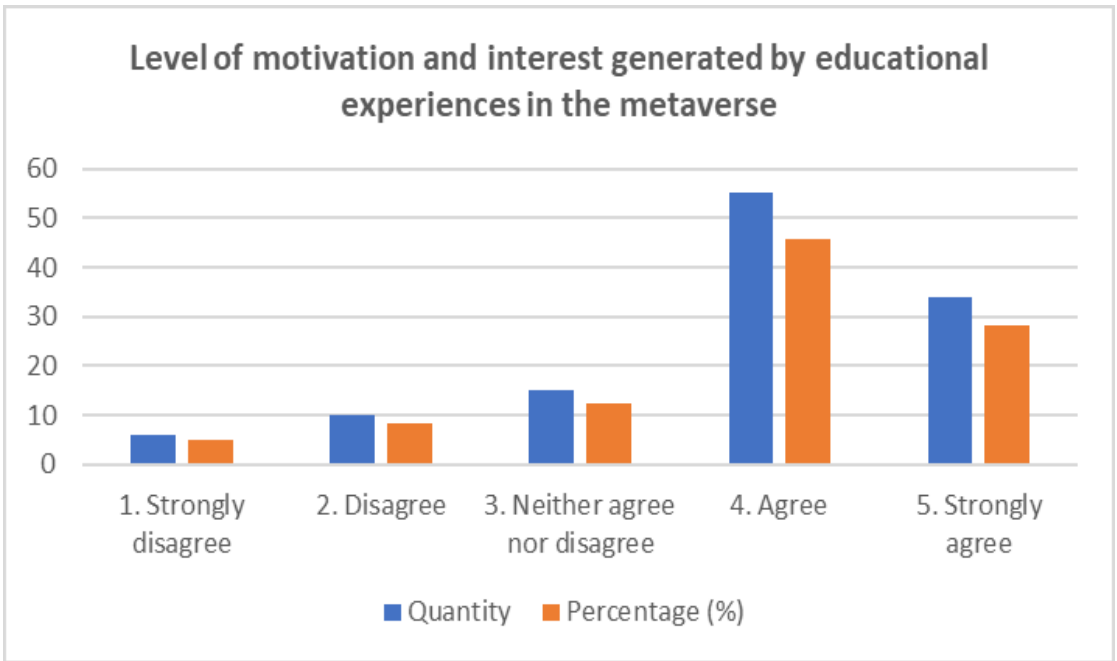

Figure 4. Do you feel that educational experiences developed in the metaverse increase your interest and motivation to learn?

74,2 % of respondents feel motivated or very motivated by educational experiences in the metaverse. This confirms that immersive environments have a positive impact on student engagement, promoting experiential learning. However, 13,3 % report low motivation, possibly due to a lack of technological proficiency or access issues. Therefore, the metaverse must be complemented by inclusive strategies that ensure the participation of all students without causing frustration or digital exclusion.

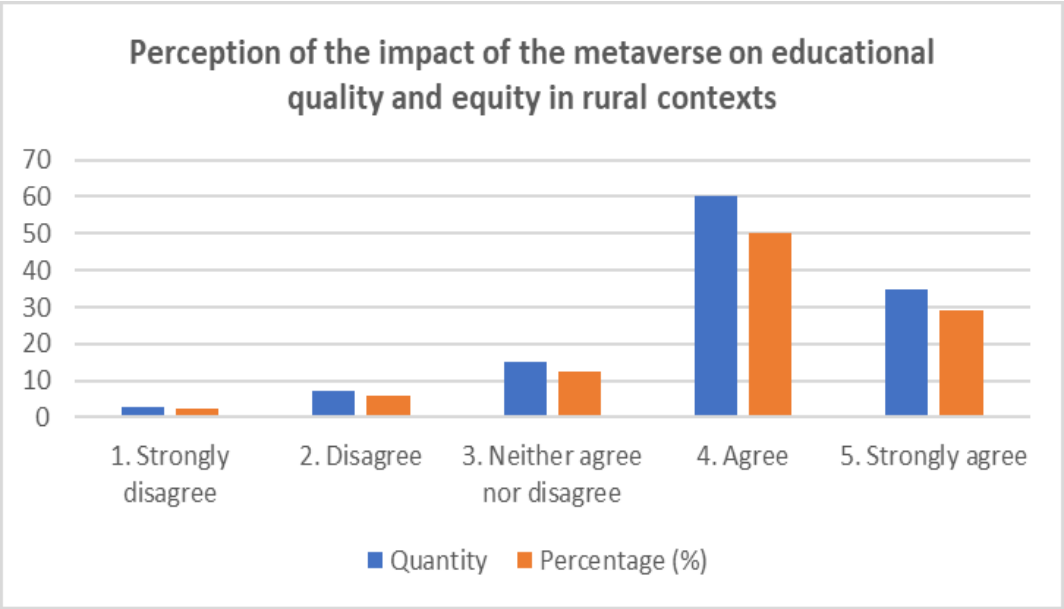

Figure 5. Do you believe that integrating the metaverse into university education can strengthen educational quality and equity in rural areas?

79,2 % of students believe that the metaverse can strengthen educational equity and quality in rural areas. This perception highlights its democratizing potential, as it allows for learning experiences comparable to those in urban contexts. However, 8,3 % hold a negative opinion, possibly due to persistent inequalities in access or connectivity. These results reinforce the need for public policies that guarantee digital inclusion and technical support in the implementation of immersive educational technologies.

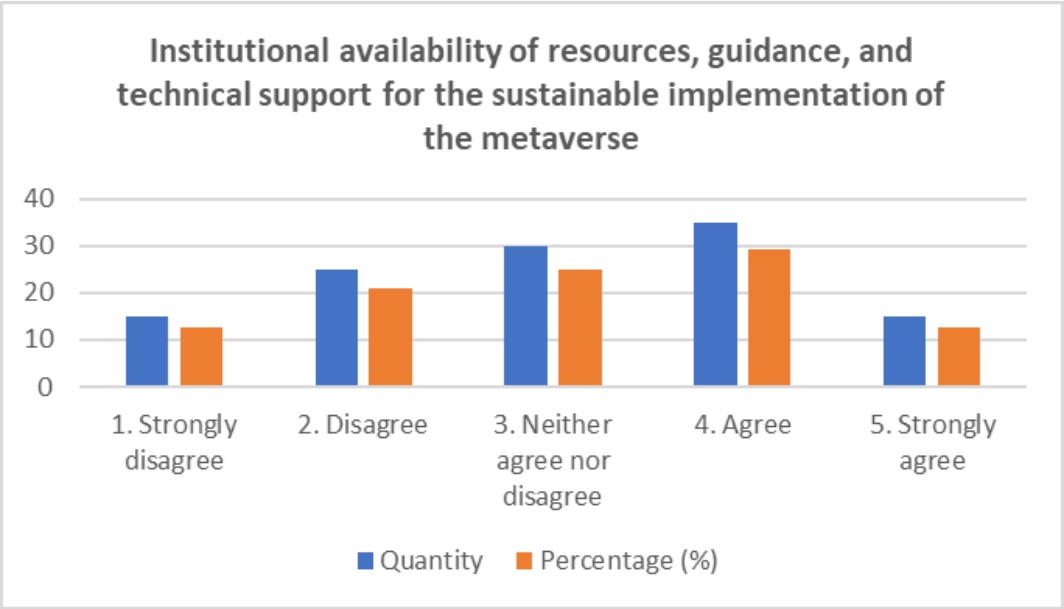

Figure 6. Does your institution offer sufficient resources, support, and technical assistance to sustainably implement the use of the metaverse in teaching and learning processes?

Only 41,7 % perceive that their institution provides sufficient resources and technical support to implement the metaverse. This reveals that, although there is institutional interest, technological sustainability still faces challenges in terms of infrastructure, financing, and technical training. The neutrality of 25 % suggests a lack of knowledge about support mechanisms. Therefore, it is recommended to create stable technical units, specific budgets, and collaborative networks to ensure the continuity and effectiveness of immersive educational experiences in rural contexts.

Results of the questionnaire administered to teachers

The results obtained from the questionnaire administered to 20 teachers from the three selected rural

universities offer a detailed view of the level of integration of the metaverse into educational processes. The instrument allowed for the identification of perceptions, attitudes, and competencies related to the adoption of immersive environments, as well as the main technological, pedagogical, and organizational barriers faced by teachers.

Interview with 20 teachers

Interviews with 20 teachers from three rural universities revealed diverse perspectives on the integration of the metaverse into teaching and learning processes. In general, participants showed curiosity and openness towards this technology, while recognizing the technical and pedagogical limitations that hinder its effective implementation. Most agreed that the metaverse represents an opportunity to revitalize teaching, especially in contexts with scarce physical resources.

From a technological standpoint, teachers observed significant differences between institutions. Some mentioned the availability of stable connectivity and well-equipped laboratories, while others reported difficulties even in delivering basic virtual classes. Despite these limitations, several teachers noted that the metaverse could reduce geographical barriers, allowing for more immersive learning experiences without the need for long and costly travel.

In terms of digital competence, most admitted that they still felt they were in the process of learning. Younger teachers or those with more recent training showed greater familiarity with digital environments, while those with longer professional careers acknowledged feeling insecure or lacking specific training. Many agreed that institutions should offer continuing professional development programs focused on the pedagogical use of the metaverse, and not just its technical aspects.

Pedagogical aspects emerged as a central theme in conversations among teachers. Several interviewees highlighted that immersive experiences can improve conceptual and practical understanding by allowing students to "experience" content that is difficult to visualize in traditional classrooms. However, they cautioned that without proper lesson planning, the metaverse could become merely a recreational tool with no real educational impact.

In terms of student motivation, most interviewees perceived a significant increase in student interest and participation when integrating immersive activities. Teachers recounted examples of students in rural areas who, for the first time, showed enthusiasm when interacting with simulations or virtual laboratories. However, some expressed concern about technological dependence and the need to balance virtual experiences with real, community-based ones.

Structural barriers were another recurring theme. Interviewees cited unreliable connectivity, the high cost of devices, and lack of technical support as significant obstacles. Institutional limitations were also mentioned, such as insufficient investment in educational innovation and the lack of clear policies to guide the integration of the metaverse into university curricula in rural areas.

Regarding the sociocultural dimension, several teachers insisted on the importance of adapting virtual content to local realities. They agreed that the metaverse should reflect the identity and knowledge of rural communities, avoiding the imposition of urban or globalized models that do not represent their context. For many, the key lies in designing experiences co-created with the students themselves and community actors.

Finally, all participants agreed that the metaverse represents a transformative opportunity if approached with strategic vision, equity, and sustainability. They considered coordination between universities, governments, and local communities to be essential to ensure the continuity of initiatives. Overall, the voices of teachers reflect a balance between hope and uncertainty: an openness to innovation, but also a clear demand for institutional support, infrastructure, and ongoing training.

DISCUSSION

The results reflect a positive perception of the potential of the metaverse as an educational tool, especially in rural contexts where infrastructure limitations tend to be greater. Most students said they had the necessary technological resources, although access gaps remain that must be addressed through institutional and public policies. This finding coincides with the work of de Obesso, Núñez-Canal, and Pérez-Rivero, who highlight the importance of digital competence as a key factor for the successful adoption of technological innovations in higher education.[16]

In terms of teachers' digital skills, the results indicate a moderate level of preparedness to design and facilitate immersive experiences. This finding coincides with the evidence presented by Castillo Obaco, Palta Valladares, and Sigüenza Orellana, who emphasize that the pedagogical use of digital technologies, such as interactive whiteboards, requires a systematic training process that strengthens the technical and didactic skills of teachers.[17] Without such training, the transformative potential of the metaverse could be limited by teachers' lack of technological appropriation.

In addition, students recognized that metaverse-based activities improved their understanding of the

curriculum content, confirming its value as a meaningful learning environment. In this regard, González López et al. demonstrated that innovative educational experiences based on collective knowledge construction promote a deeper and more collaborative understanding of learning.[18] This evidence supports the idea that immersion and interactivity within the metaverse can strengthen the assimilation of complex concepts, especially in subjects that require visualization or practical simulation.

The high levels of motivation expressed by students reinforce the positive impact of the metaverse on academic engagement. Del Moral Pérez, Villalustre Martínez, and Neira Piñeiro obtained similar results when analyzing the use of digital technologies in rural schools in Asturias, highlighting greater interest and participation among students when innovative technological environments were incorporated.[19] This motivational effect is essential for reducing dropout rates and promoting more active learning, especially in regions with limited access to diverse educational experiences.

The metaverse is also seen as an opportunity to improve educational equity by offering learning environments comparable to those in urban areas. Ruiz-Velasco Sánchez and Ortega Barba emphasize that information and communication technologies are innovative tools capable of democratizing access to knowledge and reducing educational inequalities.[20] The results of this study reaffirm this perspective, showing how immersive virtuality can help overcome the geographical and social barriers that affect rural university communities.

However, institutional sustainability remains a challenge. Although there is a desire to integrate the metaverse, universities whose students come from rural areas still face limitations in terms of infrastructure and technical support. Barbón Pérez and Fernández Pino emphasize that strategic management in higher education must link technology with institutional innovation, ensuring stable resources and policies that favor the continuity of technological projects.[21] In this context, the integration of the metaverse requires comprehensive planning that includes financing, maintenance, and ongoing training.

Another relevant aspect is the need to establish evaluation criteria that guarantee the quality of the educational use of the metaverse. Piedra Noriega et al. propose specific guidelines for the evaluation of educational technologies, emphasizing the importance of considering accessibility, usability, and pedagogical impact as essential dimensions.[22] Applying these criteria to immersive experiences would allow for the identification of strengths and weaknesses in their implementation, contributing to the continuous improvement of teaching and learning processes in digital environments.

Finally, the integration of the metaverse into university education should be understood as a process of sustainable innovation and not as a simple technological replacement. Keck and Saldívar emphasize that educational innovation is strengthened when it integrates tradition, creativity, and student experience,[23] while Arquero Avilés et al. highlight the value of communities of practice as spaces where shared knowledge and collective innovation are built.[24,25] Consequently, the metaverse represents an opportunity to transform rural education, provided that it is based on collaborative, critical, and pedagogically sound governance.

CONCLUSIONS

The research revealed that most students have the technological resources necessary to participate in immersive learning activities. However, inequalities in connectivity and equipment persist, limiting full participation. It is confirmed that technological infrastructure is a key factor in ensuring the equitable and sustainable integration of the metaverse into rural higher education.

The results show that teachers have moderate digital skills, which represents progress, although insufficient to fully exploit the pedagogical potential of the metaverse. It is necessary to strengthen continuing education and technical support so that immersive strategies can be applied effectively, contextualized, and aligned with the educational needs of rural higher education communities.

The metaverse has demonstrated a positive impact on student comprehension, motivation, and participation. Immersive environments foster meaningful learning, greater interest in academic activities, and more active engagement with curricular content. These findings reflect that, with appropriate pedagogical design, immersive technology can become a transformative tool for university teaching in rural areas.

While institutions are open to technological innovation, resources, technical support, and sustainability remain limited. Institutional policies and strategic partnerships need to be implemented to ensure infrastructure, maintenance, and ongoing training. Only then can the metaverse establish itself as a strategy for inclusion, equity, and improved quality of education in rural contexts.

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