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SYSTEMATIC REVIEW

Metaverse and education: a complex space for the next educational revolution

Metaverso y educación: un espacio complejo para la próxima revolución educacional

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ABSTRACT

The information age, the impact of Covid-19 and the fourth industrial revolution have accelerated the processes of digitization and virtualization of society. Implemented in multiple scientific disciplines and social spaces, technological advances are projected towards increasingly immersive and interconnected scenarios. The study carried out allowed the review and produce a qualitative synthesis of the possibilities of exploiting the metaverse for educational purposes. The research was carried out based on a qualitative review design, using a predefined protocol and the use of a priori categories for the analysis of emerging codes and categories. The main results suggest that the metaverse presents various benefits, services and tools that can be applied to improve the quality and access in education. It is appreciated that the construction of an educational metaverse may be possible in the future.

Keywords: Education; TIC; Educational Technology; Immersive Learning; Metaverse.

RESUMEN

La era de la información, el impacto de la COVID-19 y la Cuarta Revolución Industrial han acelerado los procesos de digitalización y virtualización de la sociedad. Implementados en múltiples disciplinas científicas y espacios sociales, los avances tecnológicos se proyectan hacia escenarios cada vez más inmersivos e interconectados. El estudio realizado permitió la revisión y síntesis cualitativa de las posibilidades de explotación del metaverso con fines educativos. La investigación se realizó a partir de un diseño de revisión cualitativa, basado en un protocolo predefinido y el empleo de categorías a priori para el análisis de códigos y categorías emergentes. Los principales resultados sugieren que el metaverso presenta variados beneficios, prestaciones y herramientas que pueden ser aplicados para mejorar la calidad y acceso en la educación. Se aprecia que la construcción de un metaverso educativo puede ser posible en el futuro.

Palabras clave: Educación; TIC; Tecnología Educativa; Aprendizaje Inmersivo; Metaverso.

INTRODUCTION

As a concept, the metaverse was coined within science fiction; however, every day, it seems perfect as a basis for tangible realities. In a more digital and interconnected world, where these multiple realities converge or occur in parallel, the metaverse emerges as a space that presents new frontiers, not only for the world of technology.

The term "metaverse," before being considered a concept belonging to various theoretical bodies, appeared for the first time in the novel "Snow Crash" by author Neal Stephenson.[1,2] It is a collective virtual universe

accessible through virtual reality (VR). In this book, the metaverse is a digital space where people interact through avatars in an alternate reality.[3]

From Stephenson's description, in which the metaverse was produced in a single street, it was conceptualized as an immersive digital space, a virtual space where people could interact in real-time in a 3D environment, characteristics that are roughly maintained in its current conception.[3]

The first constructions of these spaces for digital interaction were massively multiplayer online games (MMOs). Major platforms such as "World of Warcraft" and "Second Life" laid the foundations for the realization of the vision of the metaverse as a continuation of the Internet.[4]

Although rudimentary compared to the visions of the metaverse today, these games were pioneering projects using technology to create multi-user platforms with persistent characters where social interaction was an added value. Today, the metaverse has evolved, and multiple technologies (virtual reality, mixed reality, augmented reality, digital twin, and blockchain) have converged in it. However, it surpasses them individually.[2,5] This development of the metaverse as a post-reality has facilitated multi-sensory interaction with digital objects, virtual spaces, and people.

A combination of factors has driven the rise of the metaverse in postmodern society. The first is the advance of technology, marked primarily by improvements in VR and Augmented Reality (AR) software. This, coupled with integrating multiple technologies in hardware development, has led to increased computing power and Internet speed. As a result, increasingly immersive and interactive digital experiences have become possible.[5] These are complemented by external technological results and the development of software such as the Generative Pre-trained Transformer (GPT), which point to accelerated changes in current scenarios. The second factor is related to the cultural, social, behavioral, and aesthetic changes that characterize postmodernity. The relatively rapid emergence of generations native to the digital era, the resources implemented in information literacy, and the various advantages offered by virtual environments have made it possible to extend the use of technologies.[6,7,8]

Another aspect of this second factor is expanding hybrid and remote modalities in different human activities. The COVID-19 pandemic accelerated the adoption of digital technologies, which allowed the naturalization and familiarity of some technologies and spaces in various branches of industry and academia.[9,10] Out of this process has come an increased familiarity with technologies, interaction in virtual spaces, and using these for purposes beyond recreation. Remote work, online learning, and virtual events have become commonplace, paving the way for a deeper transition into the metaverse.

A third factor is the interest of technology companies in the development, business, marketing, and other possibilities offered by the metaverse. Companies such as Facebook (now Meta Platforms Inc.) and Microsoft have announced plans to build versions of the metaverse. These companies see the metaverse as the next big step in the evolution of the Internet and are investing significant resources to make it a reality.[11] However, despite its growing popularity and proven benefits, the metaverse also presents complex challenges to its widespread adoption. The most common and debated include privacy issues, computer and physical security, and the need for a solid foundation of technical standards, regulations, and laws governing their production, marketing, and use. In addition, there are growing concerns about the social and psychological impact of replacing physical reality with virtual environments in different human life processes and areas. This problem, which has been studied in the case of video games and the addictions derived from their consumption, is potentially alarming in proposals where the limits of time, functions, and access are not sufficiently clear.

As technology advances and society becomes increasingly digital, the likelihood grows that the metaverse will play a larger role in human development. Because the appropriate use of this perpetual and persistent environment can change how we work, learn, socialize, and interact with the world, the metaverse has been no stranger to research in the social and educational sciences. The educational use of the metaverse and other technologies that converge in it has recently gained popularity due to their versatility for teaching and learning processes in the most appropriate environments. The use of intelligent tutors, access to construction sites, and the implementation of medical protocols, among other alternatives, have shown the importance of using technological resources for educational purposes. However, using any technology for teaching and learning must be mediated by profound support. The moral and ethical aspects of these new ways of exploiting virtual environments must be reviewed. Therefore, it is not a matter of exploiting these environments lightly but a comprehensive and systematic study of their benefits and limitations, contributions and deficiencies, and possible prejudices.

METHOD

Definition of the objective of the review

This research aimed to explore the specialized literature that greatly impacts using the metaverse in education. To this end, a study was designed using priori-selected categories, specifically focusing on immersive learning experiences, collaboration and socialization, and skills practice in a safe environment.

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Rather than focusing on priori theories, such as positivist or post-positivist approaches, a flexible positioning was pursued to allow a better understanding of the phenomenon in question.[12,13] In that order, a research protocol was designed based on the recommendations proposed by Butler *et al*. (2016)for conducting qualitative systematic reviews.

Because conducting qualitative reviews is an emerging field in education, we sought to maintain reliability by applying triangulation procedures,[14] the aim was to maintain reliability by applying triangulation procedures. To this end, a strategy based on integral triangulation was used to sustain credibility and reliability during the research process.[15]

Triangulation of perspectives was implemented, as quantitative, mixed, and qualitative papers were reviewed, as well as papers from different disciplines and theoretical bodies. The researchers individually explored the selected papers and the emerging synthesis so that their analyses and contributions were triangulated. Finally, the data sources were triangulated, which will be explained below.

Source identification and selection

A comprehensive literature search was conducted in several academic databases, including JSTOR, ERIC, SCOPUS, Google Scholar, and the IEEE database. The keywords used in the search engines were "metaverse," "education," "immersive learning," "collaboration," "socialization," "skill practice," "safe environment," and combinations of these. Papers specifically focused on using the metaverse in education were selected for review.

We identified these keywords in English from this initial database and replicated the same procedure. This made it possible to diversify the search and access results from experiences in other contexts.

Evaluation of the quality of sources and inclusion criteria

All the papers selected were evaluated for relevance and quality. This involved examining the quality of the research methodology used in each study, the validity of the findings, and the study's relevance to the review's objectives. Only studies that met the quality criteria were included in the review to eliminate possible researcher bias.[16]

Data extraction

Data relevant to the review's objectives were extracted from each paper selected. This was delimited in the study population, the intervention or metaverse strategy used, the learning outcomes measured, and the study's main findings. This strategy made it possible to work with key concepts that facilitated the synthesis of the information on the basis already provided by the categories selected a priori. Having a priori-selected category made it possible to organize the data analysis more precisely without losing flexibility; three fundamental tasks were carried out in this analysis. Given that in qualitative research, data collection and analysis can occur in parallel, a qualitative content analysis was developed,[17] a qualitative content analysis was developed, based on inductive coding, which allowed the discovery and coding, the extraction or presentation of organized data and the verification of the conclusions obtained.

Summary of findings

The data extracted from the studies were analyzed and synthesized to identify patterns, trends, and common themes. Particular attention was paid to how the metaverse has been used to facilitate immersive learning experiences, collaboration and socialization, and practice skills in a safe environment. The research findings were also examined to identify the limitations and challenges of using the metaverse in education.

RESULTS AND DISCUSSION

The main results obtained are presented below. This presentation is based on the categories identified a priori and the codes identified in the data analysis.

All the databases identified in the protocol were reviewed, which made it possible to identify the study population (N=221), of which: were eliminated due to duplication (n=26), discrimination of categories in title and abstract (n=50), or specific subject matter (n=60). The remaining papers were subjected to an in-depth evaluation (n=85). Based on the triangulation of the researchers' criteria, the definitive sample (n=20) was selected as this was the minimum number of case studies for a qualitative design oriented towards grounded theory and assuming the text corpus as the data source.[18]

Immersive learning experiences

Immersive learning is one of the metaverse's most promising and exciting applications. This concept is based on converging VR, AR technologies, and 3D environments to immerse students in a virtual learning environment.

Experiences based on immersive learning suggest that this type of environment can change and revolutionize

how we teach, but above all, how we learn. The way we teach and conceptualize education as a transferential and social reproduction process would be transformed by the very practice in these environments.

Three major codes or subcategories were found in this category. Two were interpreted in close relation due to their educational implications, which include educational models and learning styles, personalization of the process, and inclusion and access. The first code was represented in the papers by the different forms of education, education, and training that converge in the pedagogical structure underlying two fundamental elements of the experiences: the design of the environment and its exploitation. In this first code, reference is made to the papers studied and to the current modalities (face-to-face, distance, and mixed) as models that can be replicated in the metaverse since it would allow the convergence in the virtual space of students from different careers and even latitudes, without affecting the face-to-face teaching and research processes in their institutions; this in the case of more complex teachings such as pre-university and university. The possibility of exploiting gamification and ludic processes in the metaverse was also appreciated for primary education and other educational levels since these have demonstrated their effectiveness in values education, attitudinal change, and other positive results in different contexts.[19]

The second code or subcategory refers to elements such as learning pace, asynchronous experience, and content reproduction. These, in turn, refer to how the user can choose to take the activities, interact with the virtual and real tutor, and control aspects of the environment, which are central elements to promoting active learning.[20]

In addition, this code explored the contributions made to dimensions such as inclusion and access, not in the technological sense, since these technologies favor using avatars and controlling environments and interactions to make them safe. To a certain extent, the concern for achieving a projection in the metaverse of educational agendas and policies, supported by studies so that evidence and deep understanding guide their exploitation was appreciated. This is fundamental, as it favors the guarantee of rights and freedoms inside and outside the metaverse; hence, the vital importance of ethnographic studies and research on leadership distribution, social transformation, and cultural consumption.[21,22,23]

Finally, the third code, called "applications," made it possible to synthesize some of the main trends and preconceptions of future ways of exploiting the metaverse for educational purposes as a possible illustration of its contributions to the various specific didactics. This code is presented independently, not because it is disconnected from the first two, but because it is the convergence of the analyses already carried out.

In the first place, there is a tendency to overcome traditional models based on face-to-face learning. In this sense, immersive experiences make it possible to combine familiar aspects, such as reading and oral communication, with novel forms of experiential learning. Unlike some forms of exploitation of the metaverse, based on socialization, these experiences allow the vivid experimentation of content and the development, through that same experimentation, of the experience of the more complex skills or competencies for which they were designed.

With applications in various disciplines, immersive experiences would allow the "direct" exploration of historical events and places. In this way, the teaching of history could be supported by the "participation" of students in certain milestones, the exploration of historical contexts, and even the exchange with historical characters. In the tourism sector, these immersive experiences have shown some success, and multiple projections,[24] in education could offer better teaching opportunities.

Another group of disciplines with a wide development, compared to the rest of the possible areas of exploitation of the metaverse, are the biological and health sciences. In these fields, immersive experiences have gained space precisely because of the advantages mentioned above:

- They offer a safe space for the experiential experimentation of content and the execution of medical procedures.
- They facilitate work at the learner's pace.
- They allow collaboration and individual work in the same scenario.

In addition, telemedicine has positioned itself as an important emerging field, which has attracted attention to the various options that the metaverse offers (diagnosis, remote medical care, and monitoring, among others).[25] According to the results shown in research, this type of immersive experience could be particularly beneficial for topics that are difficult to visualize or understand through reading or traditional teaching, in addition to facilitating feedback.[26] Even from a formative perspective, they would allow integration of the various substantive processes, such as teaching and research, as long as this integration is conceived a priori (as part of the curriculum) and does not appear as a possible non-preconceived use.[27]

For example, students could explore a cell from the inside, not only experiencing firsthand how cellular mechanisms work but also with auditory resources, deployable information sources, and other resources that are difficult to integrate into a traditional instructional process, which is still quite influential in specific didactics. Other examples are access to construction sites, geological expeditions, or other related situations beyond today's real possibilities. They are an essential part of the professional problems that future graduates

will solve.

In this sense, immersive learning and transforming teaching and research could change how we understand the *practicum and* the implementation of digital activities.[28] In addition, digital tools, the combination of activities, and the different forms of control could be beneficial for teachers, as suggested by studies such as that of López-Belmonte *et al*.[29] Not only could they offer a more personalized accompaniment at crucial moments or sensitive periods of learning, but they could also benefit from the data and metrics offered by digital platforms.

Despite the enormous possibilities, implementing immersive learning experiences in the metaverse presents challenges. One of the most obvious obstacles is access, which is one of a technological nature. VR headsets and computers with the necessary hardware to access the metaverse are still expensive, making access difficult for students, professors, and institutions, affecting learning sustainability.[30] However, studies are optimistic about the cost of these technologies in the future.

In addition, educators, designers, content creators, companies, and institutions will have to find ways to design immersive learning experiences that are educational and engaging but that are also safe and respectful of student privacy.[30] This is if we aspire to widespread use, which implies the development of standards and regulations for educational content in the metaverse, as well as the training of educators in the effective use of these tools.

Another particularly complex aspect, despite the digital tools available and to be designed, is the assessment of learning. As the mixture of educational models, ways of understanding the teaching-learning process, and other aspects that influence assessment, which constitute a space for debate in physical contexts, studies suggest that traditional tests and exams (mainly standardized ones) may not be adequate to assess the skills and knowledge acquired through immersive experiences. This accentuates the need for deep reflection to develop new forms of assessment appropriate for this new learning environment. In addition, it represents a fundamental epistemological challenge, as it requires a serious epistemic dialogue as a basis for the proposals and the ways to evaluate them.

Finally, it is crucial to highlight that the literature points out that immersive learning experiences in the metaverse should be considered as something other than traditional teaching and learning. This aspect, of profound ethical, social, and even labor implications, accounts for the importance of conceiving these resources as complementary tools. Direct human interaction and the guidance of an educator remain fundamental to the learning process. However, the metaverse can offer new ways of exploring and understanding the world. However, it should not be considered a substitute for the humanistic sense of interaction, the most humane forms of help, and face-to-face accompaniment. Even under current conditions, the inadequate use of available digital platforms and the abuse of non-face-to-face have raised doubts about the large-scale use of distance education. Fundamentally, during the COVID-19 pandemic, and certainly aggravated by it, indicators of discomfort were seen in both students and professors.

Collaboration and Socialization

Task-based collaboration and socialization are two fundamental aspects of education that have been greatly affected by digitization or virtualization and the transition to new learning models, including educational platforms and software. In this sense, studies suggest that the metaverse presents varied opportunities to enhance and enrich these interactions.

First, the metaverse can facilitate collaboration among students, regardless of their physical location. Students can collaborate in a three-dimensional virtual environment to work on group projects, share ideas, and solve problems. In addition to interacting in real-time by using avatars to represent themselves, they have digital tools to manipulate digital objects or build them in virtual space.

Two codes were found in this category: collaborative learning and group space for learning.[31] The first code alludes to the multiple forms of collaboration that can be exploited in the metaverse since, in addition to transferring experiences already known and used in current education, the design of the environment would make it possible to generate new supports for them or even new ways of thinking about collaborative learning.

Some of the usual ones are teamwork, different forms of peer evaluation, and the professor's participation in problem-solving or activity development. However, the metaverse offers the opportunity (always depending on the designed environment) to interact directly and in an intuitive, creative way. It also allows us to execute resources and tools in real-time and in a shared way; that is, it allows us to overcome the processing in analogical environments and the current digital platforms.

The rise of distance and blended models in the different stages of the COVID-19 pandemic highlighted a fact known to Distance Education (DE) specialists and users. Despite the implementation of different models of e-moderation, tutorial organization, and the integration of communicative schemes, experiences described as loneliness, anxiety, and depression were and are diagnosed in the different uses given to virtualization and digitalization of teaching and learning processes.

These experiences point to the need to create support groups, linking communities oriented to specific purposes, and quality interaction in the same environment, not through the combination of social networks, messaging services, or other means. However, these have proven their usefulness in different studies.[32] It follows that, in addition to learning that responds to specific subject objectives, the metaverse offers multiple opportunities for guidance and the provision of services that contribute to the integral development of users. In this sense, students can meet in virtual environments to talk, play games, or spend time together, just as they would in a physical environment. This can help the formation of connections, academic networks, and communities. The sense of belonging and mentoring possibilities, coupled with the advantages outlined above, are particularly important in distance education and would help alleviate many of its current inadequacies.

By providing a relatively safe space for social interaction, the metaverse can help alleviate these problems and improve the learning experience, not only academically. Integrating aspects of human well-being and academic performance represents a significant advance in collaboration and socialization. In this sense, continuing to refine virtual environments precisely regarding this well-being is a central line of development for both the metaverse and education.[33,34]

It is important to note that, as with any technology, using the metaverse for collaboration and socialization must be done responsibly. Educators and system administrators must ensure that the metaverse is a safe and respectful space for all students. This may involve incentivizing behavioral policies, monitoring interactions, and providing supportive student resources. Thus, the main limitations noted in the study of this category have to do with ethical, cultural, and organizational aspects. The main concern and object of future study is how the metaverse would be instituted as a meta-space for cultural construction.

Skills practice in a safe environment

This category, although closely related to codes that have been addressed previously, stands as a code in its own right. Moreover, its study marked the saturation limit and offered guidelines for the closure of the data analysis, the identification of limitations, and possible future developments.

As noted previously, practicing skills in a safe environment is one of the most significant advantages the metaverse can bring to education, at least in its instructional sense. The metaverse can act as a virtual "testing ground," allowing students to explore, experiment, and learn from their mistakes without the risk of physical harm or costly consequences; this represents a significant advance over the physical constraints of didactic processes limited by funds, materials, or other aspects.

The studies reviewed reveal its importance in the field of medical disciplines. In the case of future surgeons, the metaverse provides benefits in the safe practice of surgical procedures. Since surgery requires the development of multiple professional competencies and physical skills that guarantee the precision, coordination, and efficiency of its action on the human anatomy, the safe burial in safe conditions, and the safe application of experimental proposals, among other applications, represent an important advance.

These proposals not only overcome the traditional alternatives based on practicing skills on cadavers or mannequins but also make it possible to overcome less sophisticated and less accurate virtual environments. As these methods present operational limitations, these new exercises must be understood in terms of all the benefits reviewed and the proportion of real-time feedback on student performance, which also transcends the possibilities of physical environments.

Similarly, formative and summative assessments allow for a more critical, less reproductive, and practice-oriented process. In the metaverse, students could practice 3D virtual models of human bodies that are anatomically accurate and respond realistically to medical interventions. They could practice the same operation repeatedly, receiving immediate feedback on their techniques and adjusting them accordingly. This would allow them to develop their skills and confidence in a safe environment before working with real patients.

The metaverse can also provide a safe and efficient environment for engineering and design students by combining already employed educational models such as formative learning, flipped classrooms, and blended learning. Thirty-five students could simulate and test their designs in a virtual environment instead of building costly and time-consuming physical prototypes. They could experiment with different materials and configurations, observe how their designs behave under different conditions, and make adjustments as needed. This would allow them to iterate and improve their designs more quickly and efficiently and provide them with a deeper understanding of engineering and design principles.

Likewise, practice in a virtual environment can be particularly useful for developing skills that are dangerous or difficult to practice in the real world. For example, aviation students could practice difficult or emergency flight maneuvers in a virtual flight simulator before attempting them in a conventional aircraft. Chemistry students could perform dangerous or expensive experiments in a virtual laboratory, eliminating the risk of injury or property damage.

As can be seen, the metaverse, as a concept and a reality, not only represents the next evolutionary step of digital technologies. It also represents an opportunity to analyze and transform reality based on constructing

new models rather than revising epistemic models and traditional ways of doing things. In this sense, education, as a social institution and process of cultural transfer, can be one of the main components of postmodern society to benefit from the conscious and intentional integration of these technologies, especially the metaverse. However, as with any human or technological process, this integration represents challenges, opportunities, and dangers.

The main limitations observed tend to have a complex epistemological charge since they are based either on uncritical/spontaneous exploitation or on the exploitation of the metaverse without evidence to support the arguments underpinning the proposals. The tendency points towards experimentation in applying different models or schemes of the functioning of the metaverse rather than constructing an educational one, which is perhaps still an unfeasible endeavor. In this item, it is essential to emphasize evidence and data mining,[36,37] as well as the use of methods that allow a deep understanding based on systematic reviews.[14]

As for the study, due to its epistemological positioning and objectives, its main limitations lie in the size of the sample, its regional limitation, and the in-depth study of categories selected a priori. Future developments are foreseen in the theoretical rather than practical sphere, the substantiation of alternatives based on comprehensive systematic reviews that integrate qualitative and quantitative data, as well as the development of guidelines for educational policies and decision-makers.

CONCLUSIONS

Immersive learning experiences in the metaverse have the potential to revolutionize education. Providing an engaging, interactive, and personalized learning environment could improve students' understanding, performances, and, ultimately, academic achievement and holistic development. However, realizing this potential requires careful and detailed consideration of the challenges and opportunities presented by this integration of technologies and epistemic, social, and cultural models. As we move toward an increasingly digital future, these platforms must be the collaborative design of educators, policymakers, stakeholders, and technology developers.

Also, the metaverse offers opportunities to enhance collaboration and socialization in the educational context. Providing a space for real-time and 3D interaction can make collaboration more effective and socialization an enriched and accessible process from different physical spaces. This interconnectedness can be a crucial factor in enriching the experience for the student body, not just from learning. However, security, privacy, and equity challenges must be addressed to ensure that all students benefit from these opportunities.

The metaverse can provide a safe and efficient environment for students to practice and develop skills. By allowing students to experiment, make mistakes, and learn from them in a "risk-free" environment, the metaverse can improve the quality of education and better prepare students for the real world. However, it is important to note that virtual practice should only partially replace the *practicum* in real, tangible contexts where their future professional performances will ultimately be required.

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FINANCING

None.

CONFLICT OF INTEREST

They do not exist.

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