



REVIEW

Collaborative Learning in Immersive Virtual Environments: A Review of Its Potential in Secondary Education Through Interaction in Metaverses

Aprendizaje colaborativo en entornos virtuales inmersivos: una revisión sobre su potencial en la educación secundaria desde la interacción en metaversos

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ABSTRACT

Collaborative learning in secondary education has been recognized as an effective strategy for the development of social, cognitive and emotional skills. In parallel, metaverses have emerged as virtual environments with the potential, to enrich educational interaction through immersive experiences. This article reviews, how collaborative learning is articulated within metaverses, especially from the social, cognitive and emotional dimensions. A narrative review of scientific literature published between 2018 and 2024 in databases such as Scopus, Springer and indexed journals was conducted. Case studies, pilot experiences and theoretical models applied to collaborative learning in immersive environments were analyzed, with emphasis on high school students. The reviewed studies show that metaverses favor teamwork through interaction between avatars, co-construction of tasks and real-time communication. Benefits such as increased motivation, development of social skills and situated learning were identified. Challenges such as the need for teacher training, intentional design of activities, and attention to technological equity were also noted. Collaborative learning in metaverses offers opportunities to transform educational practices in secondary school. To achieve this, solid pedagogical planning, effective teacher mediation and educational policies that guarantee access and inclusion are required. It is proposed to strengthen research and specialized teacher training in immersive virtual environments.

Keywords: Collaborative Learning; Metaverse; Educational Interaction; Secondary Education; Immersive Environments.

RESUMEN

El aprendizaje colaborativo en educación secundaria ha sido reconocido como una estrategia efectiva para el desarrollo de habilidades sociales, cognitivas y emocionales. Paralelamente, los metaversos han emergido como entornos virtuales con potencial, para enriquecer la interacción educativa mediante experiencias inmersivas. Este artículo revisa, cómo se articula el aprendizaje colaborativo dentro de metaversos, especialmente desde las dimensiones social, cognitiva y emocional. Se realizó una revisión narrativa de literatura científica publicada entre 2018 y 2024 en bases como Scopus, Springer y revistas indexadas. Se analizaron estudios de caso, experiencias piloto y modelos teóricos aplicados al aprendizaje colaborativo en entornos inmersivos, con énfasis en estudiantes de secundaria. Los estudios revisados evidencian que los metaversos favorecen el trabajo en equipo mediante la interacción entre avatares, la co-construcción de tareas y la comunicación en tiempo real. Se identificaron beneficios como mayor motivación, desarrollo de habilidades sociales y aprendizaje situado. También se señalaron retos como la necesidad de formación

docente, el diseño intencional de las actividades y la atención a la equidad tecnológica. El aprendizaje colaborativo en metaversos ofrece oportunidades para transformar las prácticas educativas en secundaria. Para lograrlo, se requiere una planificación pedagógica sólida, mediación docente efectiva y políticas educativas que garanticen el acceso y la inclusión. Se propone fortalecer la investigación y la formación docente especializada en entornos virtuales inmersivos.

Palabras clave: Aprendizaje Colaborativo; Metaverso; Interacción Educativa; Educación Secundaria; Entornos Inmersivos.

INTRODUCTION

Collaborative learning has been and continues to be one of the most valued pedagogical strategies for strengthening adolescents' cognitive, social, and emotional skills, especially in secondary school. At this stage, the goal is to acquire knowledge and develop soft skills: working with others, communicating better, constructing meaning together, solving problems collectively, even when there is disagreement, and thus, little by little, providing a more complete and comprehensive education.

However, the arrival of new educational technologies has taken a different turn. Today, some platforms are no longer limited to the classroom or text. Metaverses, for example, have begun to generate curiosity among teachers and researchers. Why? Because they allow for a three-dimensional, immersive experience where students, represented by avatars, can interact with others in real-time, exploring, solving problems, and trying things out from anywhere and collaboratively.

These virtual spaces combine many technologies: artificial intelligence, dynamic graphs, physics engines, spatial sound—all of that. And that makes students not only participate but live it—literally. They interact with objects and with other classmates and feel like they are inside the environment. This eliminates, or at least reduces, many of the limitations of the traditional classroom.

When we talk about learning in metaverses, three key dimensions cannot be ignored: the social, the cognitive, and the emotional. All three are intertwined. The possibility of having a shared presence, taking on different roles, or using gestures or nonverbal expressions through the avatar—all of this can add up. Or it may not work if care is not taken because there are also risks. For example, what about regulating participation or how to promote critical thinking within the metaverse?

This article reviews recent studies showing how collaborative learning fits into the metaverse but from this threefold perspective: the social, the cognitive, and the emotional. And with a clear focus on secondary school students. It analyzes benefits, limitations, and challenges and proposes a path for policymakers and teachers to use these virtual spaces intentionally and meaningfully so that learning is more meaningful.

Collaborative learning: foundations and characteristics

Collaborative learning is conceived as an educational strategy that promotes the joint construction of knowledge among students. Unlike cooperative learning, where tasks are divided among group members, the collaborative approach involves interdependent participation. Students not only share responsibilities but also engage in dialogue, agree on decisions, and reflect together on the process and the results obtained.⁽¹⁾ This dynamic, which is more complex in terms of communication and relationships, enhances the development of skills such as argumentation, emotional regulation, collective decision-making, and active listening. This is particularly important at the secondary level, where group work becomes a key space for socialization.

From a social constructivist perspective, thinkers such as Vygotsky have highlighted the central role of social interaction in constructing knowledge. According to this view, learning does not occur in isolation but through exchange, dialogue, and symbolic and affective mediation between subjects.⁽²⁾ Under this logic, collaborative learning is not limited to achieving an academic result but transforms the learner by placing them in constant relation with others who are also constructing knowledge. In this sense, it becomes a space where collective meanings are generated, where even mistakes become shared learning opportunities.

In recent years, the emergence of digital tools has expanded the boundaries of collaborative learning. Online work, asynchronous forums, interactive platforms, and virtual environments have transformed how students collaborate. In many cases, these tools have overcome the geographical and temporal limitations of the classroom, but they do not always manage to reproduce the richness of face-to-face interaction. With the emergence of metaverses, this landscape is changing again with the introduction of a new type of experience: one that combines sensory immersion, virtual agency, and real-time collaboration within three-dimensional scenarios.

Metaverses as immersive learning environments

The metaverse concept refers to a persistent, three-dimensional, digitally generated virtual environment

where multiple users can interact with each other and with elements of the space in real time. This interaction occurs through avatars, which introduce a layer of digital representation that can be customized. These spaces are not homogeneous; they combine technologies such as augmented reality, graphics engines, physical simulations, artificial intelligence, and even blockchain systems, resulting in immersive, complex, and highly dynamic experiences.⁽³⁾

From an educational perspective, interest in metaverses has been growing. The reason? Their potential is to create scenarios where students are not limited to receiving information. They manipulate it, explore it, and reconstruct it together with others. Actively. By being exposed to visual, auditory, and kinesthetic stimuli within a shared environment, students are immersed in a learning experience that can be more meaningful. This becomes especially relevant for those who require an approach that transcends the verbal or written, as it involves different learning styles.⁽⁴⁾

One of the most notable features of these environments is the sense of co-presence, which is the perception of being there simultaneously with others. This feeling, which is intensified by avatar representation, facilitates the construction of social bonds in virtual contexts. It is not just about being connected but about feeling that you share a common space. In addition, by recreating authentic contexts or situations, metaverses allow for the design of contextualized, challenging tasks with real or simulated purposes, strengthening situated learning.⁽⁵⁾

In short, rather than a decorative environment, the metaverse functions as a pedagogical setting with multiple layers of interaction. A space that, if well structured, can expand the possibilities of collaborative learning and make it more dynamic and meaningful, always depending on the pedagogical purpose that guides it.

Social, cognitive, and emotional interaction in virtual worlds

In metaverses, the quality of the collaborative learning experience does not depend solely on the technology itself but on the type of interaction between participants and between them and the digital environment. Garrison and Anderson, using the Community of Inquiry model, propose three fundamental types of presence for understanding educational processes in digital spaces: social, cognitive, and teaching.⁽⁶⁾ This analytical framework can be adapted to understand the dynamics that emerge in immersive virtual worlds, particularly in scenarios where collaborative work is implemented.

Social presence understood as the ability of participants to project themselves emotionally and relationally into the environment, is enhanced in these spaces thanks to the personalization of avatars, body language, verbal exchanges, and spontaneous interactions. Students are not only present; they feel present. And that makes a difference. It is from this presence that the connections that sustain collaborative learning emerge. Empathy, a sense of group, mutual recognition—all of this counts.

On the other hand, cognitive presence manifests itself in the collective construction of meaning, which is activated through tools such as simulations, the creation of virtual objects, or the resolution of challenges. These activities invite students to reflect, analyze, and think critically, not in isolation but as a group. This type of presence is strengthened when students can explore ideas, discuss them, contrast them with those of their peers, and reach consensus or disagreements that they construct.

The third dimension, teacher presence, is more subtle in immersive environments, although it remains essential. The teacher is not always visible, but they are there, guiding, structuring, and offering feedback. Their role changes: they are no longer the direct transmitter of content but rather a facilitator who designs collaborative experiences, mediates any conflicts that may arise, and ensures that learning objectives remain clear and achievable.

Finally, there is an emotional dimension that often takes a back seat but takes on an unexpected prominence in these environments. The feeling of immersion, the ambient sounds, the synchronous challenges, and the interaction between peers generate emotional responses that directly affect the learning experience. Learning does not only take place with the mind. It also takes place through emotion, through what it feels like to collaborate with others, to achieve something together, or even to fail and try again.⁽⁷⁾

Secondary education and collaboration in immersive environments

Secondary education represents a key moment in students' lives. It is a stage in which not only previous learning is consolidated but also more complex skills such as critical thinking, self-regulation, and understanding of social realities are refined. This is precisely where collaborative learning can have the greatest impact because it responds directly to the needs for socialization, exploration, and identification that predominate in adolescence.

Introducing immersive environments at this level of education is not just a technical innovation. It is also a commitment to transforming the way students interact with each other and with content. Recent research has shown that adolescents respond enthusiastically to immersive virtual experiences, especially when organized around collaborative dynamics. Role-playing, conflict resolution, and collective challenges generate high levels

of motivation and engagement in these environments.

But it's not all positive. Certain obstacles have also been identified. These include the distraction that these environments can generate, their use for recreational purposes, which sometimes overlaps with educational purposes and the need for constant guidance from the teacher.⁽⁸⁾ For this reason, the role of teachers remains irreplaceable. Even in virtual environments, teachers act as instructional designers, moderators of interactions, and facilitators of learning. Their timely and well-structured intervention can make the difference between a scattered activity and a meaningful learning experience.

In this sense, collaboration in metaverses in secondary education should not be seen as a simple extension of digital classes but as an opportunity to create learning spaces adapted to the evolving characteristics of students. Spaces where not only the acquisition of knowledge is encouraged but also teamwork, empathy, and the joint construction of meaning.

Review of recent studies and relevant experiences

International studies on collaboration in immersive environments

In recent years, integrating collaborative learning in immersive virtual environments has sparked a growing interest in education. Although most research has focused on the university level, experiences, pilot projects, and case studies are beginning to emerge in secondary education. These initiatives allow us to observe specific trends and explore pedagogical possibilities that, while not yet fully consolidated, are already showing promising results.

A study conducted by Pellas et al. (2022) compiled and analyzed more than 100 educational experiences based on immersive virtual reality at different school levels. One of the most consistent findings was that when collaborative activities are well designed and receive adequate teacher mediation, there is a higher degree of emotional engagement, interpersonal skills are strengthened, and students' academic performance improves.⁽⁹⁾ In particular, three-dimensional environments were especially effective in promoting joint problem-solving in simulated scenarios, both realistic and fictional, as long as they were related to the curriculum content.

A notable example of this approach can be found in the EcoMUVE project, developed by researchers at Harvard University. In this experience, secondary school students explored a virtual ecosystem to investigate environmental issues. They took on scientific roles, collected data, developed hypotheses, and worked as a team to solve the case presented. All of this took place within a multiplayer environment. The results showed progress in the understanding of scientific concepts and a clear improvement in collaboration among students, who expressed a positive perception of using avatars as a means of interaction.⁽¹⁰⁾

Also relevant is the work of Jensen and Konradsen (2018), who analyzed how virtual worlds allow for "anchored learning": experiences in which students must solve problems embedded in a narrative or specific context. This methodology, applied in collaborative educational games, not only strengthened critical thinking but also increased the intrinsic motivation of the participating adolescents. The story, the challenge, and the common goal sustained active participation.⁽¹¹⁾

These studies suggest that the key to collaborative learning in immersive environments lies not only in the technology used but also in the pedagogical intent of the design in other words, how the experience is organized, what role is given to the student, what role the teacher plays, and what objectives guide the interaction.

Experiences applied in school settings

Although the use of metaverses in secondary education is still in an experimental phase in many regions, specific cases already allow us to observe how this technology can be applied in real contexts. These experiences, while not widespread, offer valuable insights into the conditions necessary for implementation and the benefits and challenges of integrating immersive environments into collaborative learning processes.

A representative example can be found in Finland, with the pilot project known as "Virtual School." In this initiative, students between 14 and 16 participated in a simulation developed within Minecraft Education Edition. The purpose was to resolve a fictional territorial conflict through team negotiation and cooperation. Each group had to propose peaceful strategies, defend their proposal to the others, and collectively build an agreement. Interestingly, several teachers noticed changes in the behavior of some students who usually remained on the sidelines in face-to-face classes. They were participatory and expressive this time, with clear ideas and solid arguments. In this case, the synchronous interaction between avatars facilitated a more open type of communication, less conditioned by face-to-face factors such as shyness or the judgment of the environment.⁽¹²⁾

Significant experiences are also being developed in the Latin American context. For example, the University of Antioquia in Colombia implemented an educational metaverse for secondary school students to teach history. Young people explored virtual scenarios representing key moments in Latin America's struggles for independence. Within this environment, each student took on the role of a historical figure, allowing them to

collaborate in reconstructing interactive narratives. Beyond the specific content, the experience promoted narrative skills, group work, and historical empathy that are difficult to achieve with traditional expository methods.⁽¹³⁾

Both cases reveal that the impact of these experiences does not depend solely on the technological level of the platform. In reality, the determining factor is how collaborative activities are pedagogically integrated into the virtual environment. When curriculum content, instructional design, and teacher guidance converge clearly, immersive learning is viable and can offer qualitative benefits regarding participation, motivation, and conceptual depth.

Key components in the experiences reviewed

When analyzing the experiences documented in real educational contexts, certain elements recur in collaborative activities that have achieved good results within metaverses. These components are not always present in the same way or with the same intensity. Still, their recurrence suggests that they play a structural role in the pedagogical design of immersive environments.

One of the first aspects that stands out is the presence of authentic tasks, that is, activities that are not only aligned with the curriculum objectives but also have a shared, concrete purpose that makes sense to the group. These tasks often involve challenges that require real collaboration, where it is not enough to divide the work: building collectively, making joint decisions, and negotiating ideas are necessary. When this happens, students' emotional and cognitive involvement, as does their sense of belonging to the task, tends to increase.

Another essential component is the synchronous interaction between avatars. The ability to communicate in real-time, supported by verbal language, avatar movement, and spatial arrangement, creates a sense of presence that is difficult to replicate in traditional virtual environments. This feeling of being there with others promotes the formation of bonds, facilitates task monitoring, and encourages spontaneous participation. It is not just about being connected but about being in the same shared learning situation.

The use of narratives or challenge-based structures is also frequently observed. Rather than presenting isolated content, many of the most successful experiences articulate learning around a story, a conflict, or a group goal that needs to be achieved. This strategy not only contextualizes knowledge but also contributes to group cohesion. The greater the narrative coherence, the greater the sense of common purpose.

The teacher's role is an irreplaceable element in all experiences. Their function is not only technical nor limited to observation: They organize the activity, define roles, guide participation, and provide formative feedback when necessary.⁽⁷⁾ In environments as dynamic as metaverses, this mediation ensures that collaboration does not become diluted or chaotic.

Finally, although it may seem minor, choosing accessible technologies is also essential. While some proposals use advanced virtual reality devices, many others opt for simpler tools, such as OpenSim or Minecraft, indicating that it is not technological sophistication but a meaningful pedagogical design that guarantees success. The important thing is that the environment allows for meaningful interaction beyond visual effects or technical novelty.

Limitations and challenges identified

Despite the advantages observed in collaborative experiences within metaverses, studies also warn of several challenges that must be considered before implementation. Some of these obstacles are related to technical issues, others to pedagogical aspects, and many arise from the interaction between the two. It is not a question of idealizing the virtual environment but instead of recognizing its limitations and planning accordingly.

One of the main challenges identified is the learning curve associated with using the technology. Not all students are familiar with the dynamics of immersive environments. Moving around in a three-dimensional space, customizing avatars, and coordinating actions with others in real-time can initially be overwhelming. And yes, some figure it out quickly. But others need constant support. This means that the adaptation process must be planned from the initial design of the experience.

Another recurring challenge is the risk of distraction. In an environment with so many visual and sensory stimuli, it is easy for attention to shift to recreational or secondary aspects, primarily if the pedagogical purpose of the activity has not been clearly defined. Students may explore the environment without committing to the academic task in such cases. They do not lack interest; the structure does not guide them. Therefore, planning should include moments of reflection, guided breaks, and specific objectives that keep the group focused.

There are also difficulties in time management and role organization. For collaboration to be effective, clear rules must be established on how to participate, how much time to devote to each phase, and what responsibilities each member assumes. Otherwise, inequalities in participation arise: some do more, others less, and some are left out. This affects group cohesion and can lead to frustrations that undermine the experience. In addition, the persistent digital divide must be considered. Although there are metaverses that work on standard computers, the reality is that many institutions and families face limitations in connectivity,

access to adequate devices, or even a lack of appropriate spaces for work at home or school. This technological inequality can transform an inclusive experience into another exclusion source. And that contradicts the principles of collaborative learning.

Implications for the Ecuadorian educational context

In Ecuador, the use of metaverses in secondary education is still in its early stages. No clear policy or national guidelines promote their systematic implementation, although interest is already evident in specific sectors.⁽¹²⁾ Even so, the international experiences reviewed offer valuable insights into how this technology could begin to be integrated into the country's education system. It is not a question of copying models but of adapting them. It is about seeing what can work with the available resources and the concrete realities of public and private institutions.

Some initiatives could start with specific actions, such as creating virtual laboratories, historical tours in simulated environments, or collaborative exercises in social sciences within open platforms. Even interdisciplinary activities linking language, history, and technology could find a fertile ground for working with teenagers in the metaverse. Not everything has to be complex or expensive. Sometimes, all it takes is a functional environment, a clear design, and a well-defined pedagogical intention.

The bottom line is that any attempt to use the metaverse in the classroom must be accompanied by three key elements: teacher training. Without preparation, the experience is unlikely to have any educational value. Second, rigorous instructional design. It is not enough to access the platform: you have to think about how it fits in with the curriculum, the skills, and the fundamental interests of the group. And third, ongoing evaluation to allow for adjustments to be made as you go along. Find out what works and what doesn't. Listen to the students. Make changes if necessary.⁽¹⁰⁾

On the other hand, free or low-cost platforms represent a viable alternative for many educational centers in the country. Instead of waiting for millions of dollars to be invested in state-of-the-art devices, opting for more modest but effective strategies is possible. What matters is that the experiences have educational value. They should be collaborative, accessible, and meaningful to those who participate in them. It is not about technology for its own sake but how it is used to facilitate more meaningful, active, and human learning.

DISCUSSION AND CONCLUSIONS

The reviewed literature's analysis and documented experiences suggest collaborative learning in metaverses is one of the most promising, albeit still exploratory, frontiers of educational innovation in secondary education. These immersive environments allow us to rethink the space where learning takes place, shifting it from the physical to the digital and opening up possibilities for more dynamic, multisensory, and emotionally meaningful interactions. But simply moving the classroom to the metaverse is not enough. It is not just a matter of changing platforms but of changing the approach, of thinking differently about teaching and learning.

Studies show this modality is not simply an extension of face-to-face collaborative work. It has its own rules and rhythms. Co-presence through avatars, simultaneous exploration of virtual scenarios, and the joint creation of objects or narratives all form a different ecosystem. One that requires new skills, such as effective digital communication, shared leadership, and the ability to solve problems as a team in non-physical environments. It also involves collective decision-making in real time, without the mediation of physical proximity.

However, it cannot be improvised for this collaborative learning to be truly educational. It requires solid pedagogical planning—a precise teaching sequence with defined objectives, established roles, expected outcomes, and appropriate assessment mechanisms. The role of the teacher is key in this process. No longer as a transmitter of content but as a mediator, a facilitator of experiences. Their intervention must be strategic, continuous, and adapted to the group's needs. Without this guidance, the environment's potential is diluted, superficial, or counterproductive.

Another point that cannot be overlooked is the emotional dimension of these experiences. In metaverses, learning is not just logical. It is also felt. Collaboration is based on emotion, joy, enthusiasm, and even frustration. The bonds formed when tasks are well designed, and teams work well together are real, even if they occur in a virtual space. And that has an impact. It strengthens empathy, reinforces belonging, and helps build deeper relationships between students.

Regarding infrastructure, evidence shows that cutting-edge technology is not essential to implement this experience. There are accessible, open-source platforms that allow for the creation of functional immersive environments if there is a well-developed pedagogical proposal. In Latin American countries such as Ecuador, this is essential. Because there will not always be state-of-the-art resources. But there is creativity. There is a willingness to teach. There is growing digital literacy. And that can make all the difference.

However, there are still issues to be addressed—challenges that cannot be ignored. The digital divide is still present, and teacher training is uneven. Data security, student mental health, and equity in access to devices are all factors that must be addressed seriously. In addition, it is necessary to develop tools to evaluate not

only academic learning but also the quality of collaboration, the development of soft skills, and the emotional experience of the virtual environment.

In the case of Ecuador and Latin America, metaverses can become a strategic tool for promoting more active, interdisciplinary, and situated learning. But they must be incorporated cautiously, gradually, not because they are fashionable, but out of pedagogical conviction, with meaning. It is about transforming education, not disguising it as innovation. And to achieve this, we must think about students, their contexts, and what they need to learn better.

Finally, there is an urgent need to strengthen educational research in this area. This is not only from a quantitative perspective but also from qualitative and mixed approaches that allow us to understand what students and teachers experience in these environments. What they feel, what they discover, what they build. At the same time, it proposes promoting specific teacher training in instructional design for immersive environments and promoting institutional policies that not only enable technological access but also recognize its pedagogical value. Only then will it be possible to move toward a more meaningful, more collaborative education that is more connected to the challenges of the 21st century.

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