

Immersive Learning in the Metaverse with Gamification: Design and Implementation of the CAIMG Model to Improve Learning Strategies in Higher Education

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Abstract. *This paper details the Immersive Learning Cycle in the Metaverse with Gamification (CAIMG), a four-phase model (preparation, immersion, collaboration, reflection) for higher education. To validate its viability, a four-week pilot study was conducted in a software engineering course at Politécnico Colombiano Jaime Isaza Cadavid. Comparing an experimental group (n=24, Spatial.io) with a control group (n=22), preliminary results show increased motivation, reduced dropout rates, and improved procedural competencies. We conclude the CAIMG model is functional and methodologically viable, establishing the foundation for future large-scale efficacy studies.*

Keywords— *Virtual Reality, Metaverse, Gamification, Learning Strategies, Immersive Education, Experiential Learning.*

1. Introduction

In the educational field, and specifically in higher education, digital transformation has generated new opportunities to rethink teaching and learning processes. As stated in [Cabezas et al. 2024], technology currently "moves learning, allowing the efficient development of competencies and skills through procedures and techniques that, in an orderly manner, represent a tool contributing to solving situations by applying science." In this sense, the integration of the metaverse is positioned as a pedagogical response to the need for environments that transcend passive instruction, replacing traditional lectures with virtual laboratory simulations and complex problem-solving scenarios [Mishra 2026].

Given the above, immersive technologies such as virtual reality and the metaverse emerge as potential tools to create more meaningful and motivating educational experiences [Ng 2022]. The literature highlights that, by integrating these technologies with gamification mechanics under methodological coherence, both student engagement and their self-efficacy and cognitive development are enhanced [Solís et al. 2026, Lampropoulos and Kinshuk 2024]. However, designing these experiences presents a significant instructional challenge.

Historically, the design of learning experiences has relied on consolidated frameworks such as Gagné's Nine Events of Instruction or Laurillard's Conversational Framework (LCF). While Gagné's model is fundamental for structuring cognitive processing, and Laurillard's is exceptional for guiding dialogic and reflective interactions, both were conceived for traditional analog or 2D digital environments. These models do not explicitly consider the cognitive demands of 3D spatial navigation, the sense of presence or immersion, and the integration of gamification in the metaverse [Wong et al. 2024]. Therefore, there is a methodological gap, grounded in the need for an instructional model specifically adapted to the particularities of gamified immersive environments.

Therefore, this research proposes the methodological design of the Immersive Learning Cycle in the Metaverse with Gamification (CAIMG) model. This model seeks to overcome the limitations of the traditional classroom by fostering challenge-based learning, which demands an active role from the student during technical problem-solving, structuring the experience in a cyclical and flexible manner [Bonilla-Torres et al. 2023].

The main objective of this paper is to present the methodological architecture of the CAIMG model and document its initial validation through a proof of concept or pilot study implemented in a software engineering course. Through this preliminary intervention, the aim is to demonstrate the operational viability of the model and observe its initial influence on procedural competencies and student retention, laying the groundwork for future large-scale experimental evaluations.

2. Methodological Design for Metaverse Intervention

One of the fundamental steps in structuring this research was the design and subsequent preliminary validation of the proposed model. To evaluate the operational viability and the initial effect of immersive gamification on the learning strategies of university students, a pilot study was conducted, conceived as a proof of concept. This process was articulated through a proprietary model called the Immersive Learning Cycle in the Metaverse with Gamification (CAIMG). This model is grounded in curricular integration and andragogical techniques, aimed at overcoming the limited incorporation of interactive dynamics in higher education through the articulation of rewards, immediate feedback, and meaningful challenges [Briones-Zambrano 2025]. This operational structure seeks to transform the student's perception of complex engineering contents, shifting from a receptive posture to a leading role in the construction of their own knowledge [Rodríguez 2023].

For the proof of concept, the experimental group's activities focused on specific topics from the micro-curriculum; specifically, three topics were selected: the definition of roles in a software project, the interpretation of requirements, and the construction of navigation maps. For these topics, immersive scenarios were designed on the Spatial.io platform, integrating gamification elements such as scoring systems and immediate feedback, with the purpose of increasing student engagement during the knowledge acquisition process [Parco-Mullo et al. 2023, Jaramillo-Mujica et al. 2017].

To guarantee the internal validity of this intervention and isolate the technological variable, the control group addressed the exact same theoretical contents and solved the same practical exercises as the experimental group. The difference lay

exclusively in the instructional strategy: while the experimental group interacted with challenges in the metaverse, the control group received instruction through traditional lectures and solved the proposed exercises in a written format. This controlled comparative design allows for a more objective observation of the initial efficacy of the intervention, suggesting that assigning scores and challenges in the immersive environment fosters progressive engagement that is not easily achieved with traditional methods [Sviridova et al. 2023]. In this way, the CAIMG model is articulated under a systematic approach that ensures the dynamic configuration of the interaction, allowing activities to be computable and adaptable to the specific needs of higher education [Aguilar-Vera et al. 2020].

2.1. Phases of the Immersive Learning Cycle in the Metaverse with Gamification (CAIMG) Model

The CAIMG model, presented in Fig. 1, serves as the methodological architecture to implement educational activities. It is structured into four phases designed to strengthen students' learning strategies, integrating theory with practice through intrinsic incentives and game elements [Pegalajar 2021, Oliva 2017].



Figure 1. Immersive Learning Cycle in the Metaverse with Gamification – CAIMG.

It is fundamental to clarify that, although the graphic representation of the model suggests a strictly sequential flow, in its practical implementation, the CAIMG operates as a flexible and iterative system. Depending on the pace of learning, the design of the challenge, or the needs of collaborative work, students can iterate between phases in a non-linear manner (for example, advancing to the collaboration phase before completely finishing the individual immersion phase, or returning to the context phase to reinforce concepts). The purpose of each phase within this adaptive cycle is detailed below:

2.2. Description of the CAIMG Model Phases

The CAIMG model articulates the intervention into four sequential and recurrent phases, designed to strengthen students' learning strategies by integrating theory with practice in a dynamic and structured manner. Each phase is detailed below:

Phase 1: Preparation and Context. This initial phase constituted the cognitive and technical support of the experience. It includes the selection of the curricular topics to be intervened, the planning of the immersive scenarios, the configuration of avatars, and

the spatial setting within the Spatial.io platform, as well as the design of the gamified challenges. It is important to highlight that the practical exercises were designed with an identical level of complexity for both groups (experimental and control), conceiving them not as an end in themselves, but as a structured means to teach real-world skills and allow students to rehearse situations transferable to their professional practice [Stasolla et al. 2025].

A critical aspect at this stage was the process of digital literacy and adaptation to immersive technologies. Prior training sessions were implemented to ensure that participants mastered the usability of the immersive scenarios before facing the technical challenges [Veledo et al. 2019]. With the endorsement of the institutional ethics committee and the informed consent of the participants (all of whom were of legal age), a preliminary inquiry revealed that the experimental group students lacked prior experience with virtual reality devices. Therefore, an entire session was dedicated to controlled adaptation in order to mitigate cybersickness (characterized by dizziness, disorientation, or visual fatigue) [Papaefthymiou et al. 2024], as illustrated in Fig. 2. This protocol ensured that the technology acted as a learning facilitator rather than a distracting factor.



Figure 2. Immersion Session of the Experimental Group.

Phase 2: Immersion and Challenge. This phase constitutes the core of the virtual experience, where the student, through their avatar, actively interacts with the three-dimensional environments programmed in Spatial.io. The main objective is the procedural application of knowledge through exploration and the resolution of missions in three specific scenarios:

- *The Requirements Maze:* A logical-spatial challenge where students had to navigate and solve conceptual puzzles about the definition of roles in software projects and the specification of user requirements to find the exit.
- *"Rosita's" Racetrack:* An obstacle course that required correctly answering theoretical questions to advance, with the support of a Non-Player Character (NPC) named "Rosita", who provided instructional clues.
- *The Supply Chain:* A complex simulation of a professional environment (an airport with logistics zones) aimed at information gathering, actor abstraction, and functionality modeling for the elaboration of navigation maps.

The entire experience was structured on a gamification framework designed to stimulate motivation, persistence, and engagement [Zainuddin et al. 2020],

incorporating immediate feedback through the collection of "coins" and leaderboards to promote healthy academic competition. Figs. 3 and 4 show the developed scenarios, which enable the transition from theoretical understanding to practical execution [Valdés-Godínes and Angel-Rueda 2023], acting as emotional and social reinforcers in the face of highly complex tasks [Fonseca and García-Peñalvo 2019]. The progression of the challenges fosters autonomy and consolidates learning in virtual environments that emulate real professional conditions [Tusarma-Tabares et al. 2026, Nickerson et al. 2006].



Figure 3. View of the immersive scenario "Rosita's Racetrack".

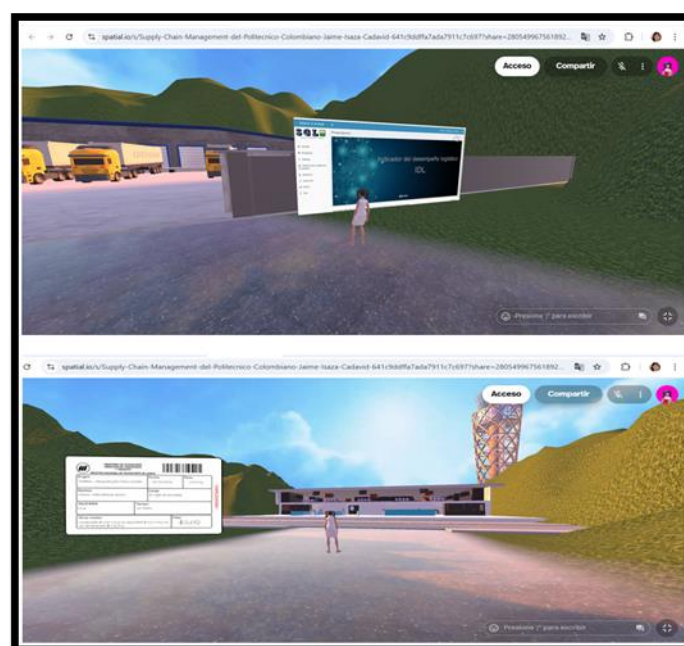


Figure 4. View of the immersive scenario "Supply Chain".

Phase 3: Collaboration and Reinforcement. Executed in a complementary manner to the immersion, this phase seeks to consolidate knowledge through social learning, organized under a dual modality:

- *Teamwork in the Metaverse:* The "Supply Chain" scenario required cooperative interaction in real-time within the virtual environment. Students had to assume specific roles and coordinate operational decisions to solve logical challenges, which stimulated assertive communication, mutual support, and long-term conceptual retention [Gutiérrez et al. 2025, Ipince 2025].
- *In-Class Reinforcement Gamification:* In parallel, the subgroups waiting for their turn to immerse participated in the physical classroom in playful activities focused on the same competencies. These included dynamics with Kahoot!, thematic crosswords, academic adaptations of the game "Who Wants to Be a Millionaire", and the construction of visual models on cardboard. In this last activity, students had to interview the guiding professor—who assumed the role of the "client"—to identify and resolve ambiguities in the case studies. This mixed face-to-face strategy enhanced cognitive presence, critical thinking, and collaborative problem-solving [Iparraguirre-Bernaola and Huamán-Huillca 2023, Ng 2022], structuring a sociocultural ecosystem where knowledge is actively co-constructed, thereby raising student satisfaction [Juárez-Negrete et al. 2025, Ipince 2025] (see Fig. 5).



Figure 5. In-class reinforcement gamification activity.

Phase 4: Reflection and Transfer. As the closure of the cycle, this phase was intentionally oriented to facilitate metacognition. At the end of each session, a space for group discussion was opened where teams presented their findings, solutions, and the difficulties encountered. The guiding professor's role consisted of steering the debate so that the students themselves could connect their practical experiences with the theoretical foundations of software engineering.

This introspection exercise transformed the immersive experience into a lasting knowledge structure [Gaintza 2024]. Following Kolb's experiential learning cycle, this stage ensures that the emotional and playful load of the metaverse translates into reflective observation and abstract conceptualization [Ortiz 2021], preparing the student for active experimentation in analogous professional contexts [Zhang et al. 2025].

2.3. Implementation Logistics and Methodological Considerations

The pilot study intervention was carried out over four consecutive weeks. Each weekly session lasted four hours (240 minutes), strategically structured to optimize technological resources, given the limited number of Oculus headsets available (10 units). To maintain active engagement among all students, the sessions were organized as follows:

- *Joint Introduction (30 minutes)*: Presentation of the day's theoretical topic to the entire experimental group. This guaranteed a standardized conceptual baseline before starting work in subgroups, ensuring equity at the starting point of learning [Íbili et al. 2024, Wolfartsberger 2019].
- *Immersion and Reinforcement Gamification Rotation (120 minutes)*: The experimental group (n=22) was divided into three subgroups (two of 8 students and one of 6) to rotate the use of the 10 headsets. While one subgroup experienced virtual immersion for 40 minutes, the other two carried out reinforcement gamification activities in the physical classroom. The rotation continued until all students completed the metaverse challenge. This design ensured pedagogically productive waiting time, fostering continuous active learning and achieving equitable access to technology [Fromm et al. 2021].
- *Closure and Metacognitive Reflection (90 minutes)*: Final plenary session where each team shared their findings, difficulties, and resolution strategies. This space fostered peer interaction and allowed the guiding professor to clarify theoretical concepts and consolidate reflections on the technology's viability.

To guarantee the study's internal validity and mitigate potential threats such as instructor effect, strict coordination was maintained with the lead professor in charge of the control group (n=22). It was rigorously ensured that both groups addressed the same topics and solved the same case studies. The independent variable was isolated in the instructional medium: the control group received traditional expository classes (whiteboard and slides) and solved the exercises in text format.

It is imperative to highlight that both groups were evaluated using exactly the same measurement instruments (pre-test/post-test questionnaires and objective tests). This comparative strategy allowed for an objective contrast of the students' academic performance and response to the gamified instruction versus the conventional method [Alazmi and Alemtairy 2024, Murillo-Zamorano et al. 2021, Delfino 2021].

Ethical Considerations and Learning Evolution

The project received formal approval from the institutional Ethics Committee. All participants signed an informed consent form that guaranteed voluntariness, ethical management, and data confidentiality. Additionally, it was emphasized from the beginning that the gamification mechanics had a strictly formative and collaborative purpose, decoupling the collection of points from any punitive grading.

Finally, the operational integration of the CAIMG model transcends the simple execution of phases. As illustrated in Fig. 6, the intervention represents a path of academic progression. During this journey, the student advances by articulately developing cognitive, procedural, and attitudinal competencies, which facilitates the

transition from a traditional passive learning model towards an active, immersive, and highly strategic learning one [Mayer et al. 2014].

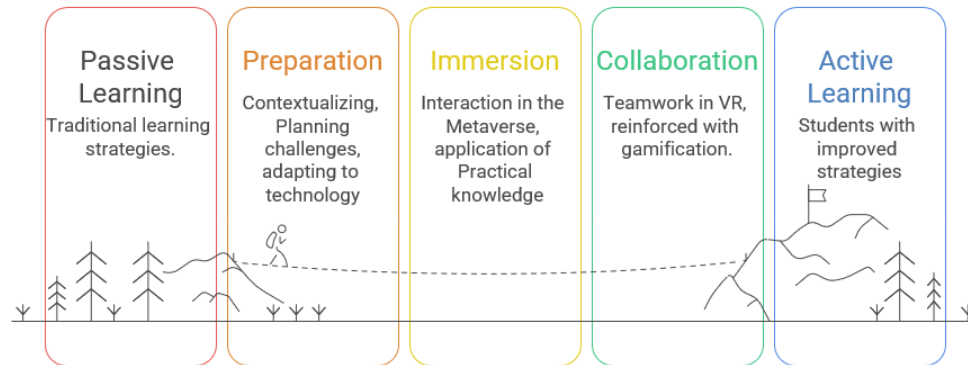


Figure 6. Immersive Learning Path in the Metaverse with Gamification.

3. Preliminary Results

When comparing the achievement of competencies in the three proposed topics using the evaluation instruments, the descriptive data from this proof of concept suggest that students exposed to the CAIMG model achieved superior performance. A more robust consolidation of procedural learning was observed compared to the control group, which used traditional methodologies.

To evaluate academic performance, the grades obtained during the four weeks of intervention in both groups were analyzed. In terms of course approval (grade ≥ 3.0), the experimental group concluded with an approval rate of 90.9% (20 out of 22 students). In contrast, the control group achieved an approval rate of 31.3% (5 out of the 16 students who finished the period).

Although the sample size ($N=46$ initially) and the design based on intact groups limit the realization of conclusive statistical inferences for this phase of the project, at a descriptive level, these findings reveal a substantial difference in academic performance. This initial trend suggests that the structured integration of technological resources facilitates a better appropriation of knowledge [Alarcón et al. 2020]. This apparent superiority is attributed to the metaverse's capacity to provide highly contextualized experiences, allowing students to interact with three-dimensional environments that facilitate the deep exploration of complex engineering concepts [Villón-Briones et al. 2024].

Additionally, classroom dynamics observations suggest that gamification fostered greater intrinsic motivation. This element was key in transforming the students' attitude toward the subject and improving their response capacity to practical problems. These preliminary results align with previous research indicating that the use of immersive environments increases not only knowledge retention but also the time dedicated to activities and peer interaction [Dutta et al. 2023].

On the other hand, a fundamental viability indicator of the intervention was manifested in the student retention rate (class attendance), a critical aspect for higher

education institutions. It is important to specify that the assignment of participants was not random, but rather intact ("natural") groups from the Faculty of Engineering of the Politécnico Colombiano Jaime Isaza Cadavid were used. Under these conditions, the control group started with 22 students and finished with 16, evidencing a dropout rate of 27.3%. For its part, the experimental group, which started with 24 students, only registered the loss of 2 participants, finishing with 22, representing a dropout rate of only 8.3%.

This descriptive gap in retention suggests that the CAIMG model is not only viable at an operational level, but could also have a positive motivational impact to mitigate early dropout. Nevertheless, from a critical perspective, it is imperative to recognize that this high retention level may be influenced by the "novelty effect" [Murcia-Rodríguez and López-Martínez 2024]. Given that no student in the experimental group had prior contact with immersive technologies, the experience transformed the class from an academic obligation into an innovative event. Even so, the fact that attendance and active participation remained constant throughout the four weeks of intervention indicates that the commitment transcended initial curiosity. This finding supports the premise that the metaverse, when integrated with pedagogical intentionality, has the potential to strengthen education and generate a higher level of participation [López-Belmonte et al. 2023].

4. Discussion

The CAIMG model integrates foundations of constructivist, experiential, and collaborative learning theories with immersive technologies, offering a methodological structure specifically designed for the digital age. Unlike previously consolidated instructional frameworks conceived for traditional environments, CAIMG proposes an architecture that capitalizes on spatial cognitive load and gamification.

Preliminary results obtained suggest that this immersive approach generates superior engagement compared to traditional instruction, favoring conceptual retention and knowledge transfer to practical software engineering contexts. The four phases of the model demonstrated facilitating both the acquisition of technical knowledge and the development of transversal competencies (critical thinking, collaboration, and problem-solving), findings that align with recent research on the pedagogical potential of virtual reality [Radianti et al. 2019, Llanos-Ruiz et al. 2021].

During the intervention, qualitative observation evidenced a notable development in teamwork and communication skills. This was facilitated by avatar-based interaction, which allowed students to function in a relaxed and spontaneous environment, mitigating social anxiety barriers regarding participation and making mistakes. Students participated actively, motivated by their training process, suggesting that the playful and adventurous nature of virtual scenarios manages to transform the perception of learning: from an individual obligation to a shared and highly participatory experience. The implementation of design elements based on rewards and narratives seems to channel students' desire for achievement, consolidating an environment where emotional commitment and social interaction translate into deeper learning [Lee and Ahn 2024].

Critical Analysis and Limitations of the Pilot Study

Despite these promising findings, it is imperative to critically analyze the limitations of this proof of concept. First, the restriction in sample size ($N=46$) and the use of intact groups limit the statistical generalization of the data. Second, there is a confounding variable inherent to the pedagogical design: the large descriptive difference observed in approval and retention rates could be partially attributed to the shift towards an active, student-centered learning approach (the core of the CAIMG model), and not exclusively to the technological introduction of the metaverse. It is well known in pedagogical literature that student-centered methods outperform passive lectures. Therefore, isolating how much of the success is due to "immersive gamification" and how much to "active learning" represents a methodological challenge that must be addressed in future studies.

Finally, the operational viability of this intervention highlights the need for higher education institutions to adapt their instructional strategies to the profiles of new generations. This proof of concept suggests that the preferences of "digital natives" for interactive environments, immediate feedback, and technological autonomy clash head-on with traditional passive models. Therefore, it is fundamental for institutions to analyze how generational diversity influences knowledge appropriation in order to design and implement hybrid or immersive models, such as CAIMG, that are consistent with the current sociocultural reality.

5. Conclusions

The Immersive Learning Cycle in the Metaverse with Gamification (CAIMG) represents a methodologically viable instructional architecture and a promising pedagogical strategy to enhance learning strategies in higher education. The model integrates four iterative and flexible phases that mutually reinforce each other, configuring a coherent, motivating, and student-centered experience. Although this proof of concept was specifically implemented in a software engineering course with students from the Professional Technical program in Information Systems Programming at the Politécnico Colombiano Jaime Isaza Cadavid, its methodological design is scalable and transferable to other disciplinary domains.

The pilot intervention articulated through the CAIMG model evidenced highly favorable preliminary trends in the participants' academic performance and retention. At a descriptive level, the results suggest that the structured integration of immersive environments and gamification offers comparative advantages over traditional lecture-based instruction, positively impacting both the appropriation of procedural competencies and the development of transversal skills. These preliminary findings support the premise that the use of immersive technologies, provided they are anchored in active methodologies, has the potential to transform teaching and learning processes.

Finally, higher education faces the unavoidable opportunity to evolve towards purely experiential models. As analyzed in this study, the value of the CAIMG model does not lie solely in the technological appeal of the metaverse, but in its capacity to orchestrate an ecosystem where the student assumes the central role, fostering their autonomy, collaboration, and intrinsic motivation. In this new paradigm, the teacher transitions towards a role of "experience facilitator", being the strategist responsible for integrating playful methodologies to respond to the demands of the current environment. To consolidate this proposal, future research should focus on the

inferential statistical evaluation of the model using larger probabilistic samples, analyze its differential impact on diverse populations, and evaluate scalability strategies in institutional contexts with limited technological resources.

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