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Gamification in mathematics: a critical look at the tensions between innovation and teaching practice in Bogotá

Gamificación en matemáticas: una mirada crítica a las tensiones entre innovación y práctica docente en Bogotá

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Abstract

In recent years, gamification has emerged as an innovative strategy in mathematics teaching; however, its implementation in the classroom remains limited. This article examines the tensions between the theoretical potential of gamification and the practical challenges faced by mathematics teachers in public schools in Bogotá. A critical review of experiences, teacher training, and institutional conditions reveals a gap between the discourse of innovation and the realities of the classroom. The lack of specific training, curricular restrictions, and limited technological infrastructure create a complex scenario for its adoption. This reflection invites us to reconsider gamification not only as a motivational tool, but as part of a broader pedagogical approach that requires transformations in school culture, the role of teachers, and educational management..

Keywords: Gamification, mathematics teaching, teacher training, pedagogical innovation, learning motivation, public education.

Resumen

En los últimos años, la gamificación se ha posicionado como estrategia innovadora en la enseñanza de las matemáticas; sin embargo, su implementación en el aula sigue siendo limitada. Este artículo examina las tensiones entre las potencialidades teóricas de la gamificación y los desafíos prácticos que enfrentan los docentes de matemáticas en colegios públicos de Bogotá. A partir de la revisión crítica de experiencias, formación docente y condiciones institucionales, se evidencia una brecha entre el discurso de innovación y las realidades del aula. La ausencia de formación específica, las restricciones curriculares y la escasa infraestructura tecnológica configuran un escenario complejo para su adopción. Esta reflexión invita a reconsiderar la gamificación no solo como herramienta motivacional, sino como parte de un enfoque pedagógico más amplio que requiere transformaciones en la cultura escolar, el rol docente y la gestión educativa.

Palabras clave: Gamificación, enseñanza de las matemáticas, formación docente, innovación pedagógica, motivación en el aprendizaje, educación pública.

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Introduction

Mathematical education has been questioned and renewed by various proposals that seek to transform its teaching through active, participatory, and contextualized methodologies. One of these is gamification, understood as the incorporation of elements from game design into educational contexts to motivate and generate meaningful learning experiences (Werbach & Hunter, 2012; Kapp, 2012). Although its use has spread to different educational levels and disciplinary areas, in the field of mathematics, resistance, doubts, and limitations for its implementation still persist. This situation raises a key question: why is a strategy that has shown benefits in terms of motivation and participation still marginalized in many mathematics classrooms, especially in contexts such as Latin America?

In Latin America, the incorporation of innovative approaches such as gamification faces structural and cultural barriers that go beyond the individual will of the teacher. Recent studies show that, although there is a favorable discourse towards pedagogical innovation, in practice, teachers must deal with rigid curricula, lack of specific training, and unfavorable institutional conditions (Zainuddin et al., 2020; Calderón, 2021).

In Bogotá, this gap between the ideal and the possible is deepened by inequalities in access to resources, work overload, and a traditional school culture that often privileges summative assessment over meaningful participation. Thus, the use of gamification becomes more of an exception than an established practice, even among those teachers who recognize its pedagogical value.

The resistance of many students towards mathematics is not only due to the difficulty of the content, but also to a deteriorated emotional relationship with the subject, marked by anxiety, a perception of irrelevance, and fear of error (Dondio et al., 2023). In the face of this panorama, gamification emerges as a strategy that not only incorporates motivational dynamics but also invites a rethinking of the very meaning of learning mathematics. By proposing challenges, levels, constant feedback, and symbolic rewards, spaces are opened for autonomous exploration, critical thinking, and the reframing of error as an opportunity (Homer et al., 2020; Scolari et al., 2018). Hence the importance of inquiring not only into the effects of gamification on learning but also into the role of the teacher as a mediator and designer of meaningful experiences.

Various investigations have demonstrated that gamification can favor both academic performance and motivation and the development of socio-emotional skills, relying on dynamic, creative, and intuitive tools that stimulate student participation (Páez et al., 2022). Furthermore, studies such as those by Högberg et al. (2019) point out that gamified experiences are powerful inducers of positive emotional states that strengthen the bond with learning. However, the success of this methodology does not depend on the simple incorporation of game mechanics, but on intentional pedagogical planning, capable of articulating playful elements with formative objectives, disciplinary content, and the particular characteristics of the students. In other words, gamification acquires educational meaning when it ceases to be a recreational strategy and becomes a purposeful didactic mediation, aimed at promoting permanent and meaningful learning.

In the specific case of Bogotá, mathematics teaching faces multiple challenges that go beyond the strictly academic. Various studies have pointed out the need to promote more transversal and creative learning environments that integrate gamification as a pedagogical strategy to revitalize student interest (Criollo, 2023; Sarmiento, 2020; Hernández, 2017). However, these efforts take place in a context marked by socioeconomic inequalities, low performance levels on standardized tests, and a notable disinterest in the subject (Rubiano, 2023; Acevedo & Ortiz, 2020; Flórez, 2024).

To these difficulties are added cultural and relational factors that affect the relationship of young people with knowledge, the loss of the cultural value of school (De la Hoz & Maestre, 2024), tensions in school coexistence (Causaso & Pacheco, 2018), and processes of exclusion that still persist in mathematics classes (García, 2025). In view of this panorama, narrative and gamified strategies emerge as an opportunity to reconstruct the pedagogical meaning of the discipline, recovering the joy of learning and strengthening understanding from more meaningful experiences (León & Cruz, 2021).

This situation demonstrates the need to adapt teaching methodologies and intentionally incorporate gamification in Bogotá's schools, especially in the area of mathematics. In this scenario, it is essential to understand how teachers perceive this strategy, their level of knowledge about its theoretical foundations and possible applications, as well as the attitudes they assume towards its curricular integration. Teacher training is therefore configured as a decisive axis; the absence of specific training in gamification can limit its implementation and significantly reduce its pedagogical impact.

This article aims to reflect on the knowledge, attitudes, and skills of mathematics teachers regarding gamification, in order to understand the factors that influence its adoption or resistance within the classroom. More than describing trends, it seeks to offer a critical and comprehensive look at how teachers perceive this strategy, what conditions facilitate its implementation, and what obstacles persist in the school contexts of Bogotá.

The analysis presented here is part of the doctoral project *"Análisis del conocimiento y de las actitudes de los docentes de matemáticas en la implementación de la gamificación como estrategia didáctica en escuelas públicas de Bogotá"* which has as one of its specific objectives to diagnose the technical skills, knowledge, and attitudes that limit or favor the effective incorporation of gamification in the classroom.

Based on this approach, a space for reflection is proposed to rethink the teacher's role in pedagogical innovation, recognizing that gamification is not a methodological fad, but an opportunity to transform the teaching of mathematics from creativity, motivation, and a meaningful relationship with knowledge.

The reflection is organized around five fundamental axes: the level of teachers' knowledge about the principles and elements of gamification; the predominant attitudes towards its use in teaching; the personal and institutional factors that influence its adoption; the strengths and weaknesses perceived in its implementation; and the implications that these findings have for teacher training and professional development in Bogotá. This approach seeks to articulate the investigative perspective with a pedagogical and transformative reading of the teacher's role, positioning gamification as a possible path towards more motivating, inclusive, and creative practices in mathematics education.

The justification for this study lies in the urgency of transforming mathematics teaching, overcoming the distance between the theoretical possibilities offered by gamification and its scarce implementation in classrooms, still marked by traditional approaches that limit participation and creativity. Understanding teachers' perceptions and experiences allows for the design of more context-adjusted support and training strategies, capable of fostering the critical appropriation of active methodologies. Reflecting on these practices not only contributes to didactic innovation but also strengthens the professional commitment of the teacher as an agent of change within public schools.

In this sense, the present work seeks to build bridges between theory, practice, and pedagogical reflection, offering an analytical framework that contributes to the continuous improvement of mathe-

matics teaching. Its results and discussions are consolidated as the basis for future research that deepens the integration of gamification and its potential to transform learning experiences in Latin American educational contexts.

Theoretical framework

Understanding the relationship between gamification and mathematics teaching requires an analysis that transcends the instrumental and situates itself in the pedagogical, cultural, and epistemological plane. In this sense, a space for reflection is constituted where ideas, debates, and perspectives that support the understanding of the addressed educational phenomenon converge. From a critical perspective, the conceptual foundations of gamification, the attitudes and knowledge of teachers towards didactic innovation, and the institutional challenges that condition its application are analyzed. These three axes allow for an integral reading of the problem, positioning the teacher not only as an executor of strategies but as a reflective agent who interprets, transforms, and re-signifies their practices in complex contexts such as those of public schools in Bogotá.

Gamification in mathematics teaching: Foundations and pedagogical scope

Gamification has emerged in recent decades as one of the most powerful strategies for re-signifying the relationship between students and learning. Its purpose is not limited to learning by playing but consists of incorporating the logics of the game within pedagogical structures to enhance motivation, commitment, and a sense of achievement (Werbach & Hunter, 2012; Kapp, 2012). From this perspective, learning is conceived as an active and emotional experience, where error ceases to be an obstacle and becomes an opportunity to explore, reflect, and improve.

In the field of mathematics education, gamification has shown positive effects on academic performance, motivation, and the development of socio-emotional skills, thanks to the use of dynamic, creative, and intuitive tools that promote student participation (Páez et al., 2022). Likewise, it has been shown that gamified experiences are powerful inducers of positive emotional states that strengthen the affective bond with learning (Högberg et al., 2019). By integrating challenges, levels, and constant feedback, autonomy, critical thinking, and problem-solving ability are promoted from a more playful and meaningful dimension (Homer et al., 2020; Scolari et al., 2018).

In this sense, gamification in mathematics cannot be understood as a set of recreational techniques but as a pedagogical approach that reconfigures the relationship between emotion, cognition, and disciplinary knowledge. Its impact transcends momentary motivation; it implies a change in the way students appropriate mathematical knowledge, favoring the construction of lasting and meaningful learning. Thus, gamification is projected as a tool to humanize teaching, transforming the classroom into a space of discovery, participation, and creativity.

Although the main interest of this work focuses on teacher attitudes and knowledge, the reviewed studies also show that gamification has a direct impact on student motivation and performance, factors that in turn affect teachers' perception and disposition towards its use. Recent research agrees that this methodology generates more active and sustained participation in learning mathematics, favoring the understanding of traditionally complex concepts and improvement in academic performance. Niampira (2023), for example, documents significant advances in the learning of fractions, algebraic terms, and

basic operations, such as addition, subtraction, multiplication, and division, from the implementation of gamified strategies. These findings suggest that the transformative potential of gamification does not lie solely in its playful component but in its capacity to redefine the student's emotional and cognitive relationship with mathematics, generating more motivating and meaningful learning environments.

In the Bogotá context, various educational experiences have demonstrated the potential of gamification as a tool for pedagogical mediation in mathematics teaching. Hernández and Sarmiento (2022) document interventions based on the use of video games and platforms like Scratch, aimed at strengthening geometry learning through the creation of interactive environments. Similarly, Aldana (2020) describes the design of gamified virtual spaces that integrate missions and challenges for teaching fractions to seventh-grade students. These experiences show that when gamification is articulated with problem-solving processes, feedback, and formative assessment, students not only improve their academic performance but also transform their attitude towards mathematics, perceiving it as a closer, more challenging, and meaningful field. Thus, the playful experience becomes a catalyst for motivation and conceptual understanding, reaffirming that pedagogical innovation must be accompanied by a formative intentionality, not merely a recreational one.

Similarly, the implementation of gamified virtual learning environments has shown positive effects on the development of mathematical competencies, particularly in problem-solving, numerical thinking, and geometric comprehension. While some studies show that student performance remains at basic levels, they also highlight a greater disposition towards learning and a more active interaction with digital resources. These experiences demonstrate that the use of missions, scores, and rewards, which are characteristic elements of gamification, favor motivation and persistence in the face of the challenges inherent in mathematical learning (Castillo, 2021).

Beyond immediate results, the incorporation of gamified strategies allows for the creation of more inclusive and participatory environments, where error is assumed as part of the process and constant feedback strengthens student autonomy. Consequently, gamification in digital environments not only expands didactic possibilities but also reconfigures the emotional relationship with learning, generating meaningful experiences that transcend the mechanical repetition of exercises and promote a deeper understanding of concepts.

Various studies agree that gamification can significantly improve learning outcomes in mathematics, especially when it incorporates immediate feedback mechanisms and playful dynamics that facilitate understanding of content by presenting it in a clearer and more attractive way. Furthermore, this methodology promotes collaborative learning environments, in which students work as a team to overcome challenges, thus strengthening their communication and problem-solving skills (García, 2021).

However, the literature also warns that the effectiveness of gamification depends on its pedagogical design. García (2021) points out that inadequate planning or poor integration by the teacher can reduce the expected positive impacts. In the same vein, Rodríguez and Visbal (2022) emphasize the need to reformulate traditional didactic strategies through gamified proposals that promote a deep understanding of mathematical concepts. All this underscores the importance of the teacher not only mastering the technical aspects of gamification but also understanding its pedagogical sense and in-

tegrating it as a tool coherent with their formative objectives.

The incorporation of active methodologies like gamification in mathematics teaching depends, to a great extent, on the dispositions and knowledge of teachers. It is not enough for digital tools or innovative didactic strategies to exist; their appropriation requires teachers capable of interpreting, adapting, and re-signifying these proposals according to their school context. In this sense, pedagogical knowledge and attitudes towards innovation constitute decisive elements that mediate between theory and educational practice (Marcelo & Vaillant, 2013; Fullan, 2007). Evidence shows that when teachers understand the formative sense of gamification and feel competent to apply it, its impact in the classroom is deeper and more sustained, while a lack of understanding or confidence can generate rejection or superficial use of the strategy (Calderón, 2021; Ponte et al., 2019).

Recent studies show a notable variability in the level of knowledge that mathematics teachers possess about gamification and its pedagogical principles. Although a significant portion of the teaching staff has heard the term or has a general understanding of its purpose, few manage to identify in depth the mechanics, dynamics, and components of game design that support its educational application (Werbach & Hunter, 2012). This conceptual gap reveals that, beyond technological novelty, many teachers still perceive gamification as a recreational resource, without recognizing its epistemological potential to transform teaching. Understanding how rules, levels, or rewards can align with learning objectives requires not only technical skills but also solid pedagogical training that allows reinterpreting the logic of the game within teaching and assessment processes.

A considerable number of teachers associate gamification almost exclusively with the use of points, badges, and leaderboards, reducing its scope to a practice of superficial reward or competition. This view, known as "pointification," reflects a limited understanding of the approach and often leads to ineffective implementations, where game elements are added decoratively, without a pedagogical integration coherent with learning objectives. As Palacios and Cimas (2024) point out, although many educators have heard of gamification, only a minority manage to distinguish the types of players or the motivations that this strategy seeks to activate. This gap between technical knowledge and pedagogical sense evidences the need for deeper training in instructional design and motivation theories, so that gamification is not reduced to a passing trend but consolidates as a transformative tool for mathematical learning.

The absence of specific training in gamification constitutes one of the most persistent factors explaining the identified knowledge gaps among teachers. Cáliz, Cerón and Hernández (2024) point out that when educators do not master the necessary technological tools or didactic strategies, their capacity to design innovative and meaningful learning experiences is limited. This lack not only affects the integration of gamification in the classroom but also widens the digital and pedagogical gap between those who are trained to teach and those who learn in technology-mediated environments.

In this sense, gamification represents an opportunity to reconfigure teaching processes, integrating game dynamics that promote exploration, creativity, and active learning. However, its implementation demands continuous teacher training, oriented towards understanding both the theoretical foundations of the approach and its potential to strengthen student motivation and academic performance.

The most consistent results in the implementation of gamified strategies are associated with training processes that equip teachers in their design and pedagogical integration. When the instructions for developing activities are clear, dynamic, and articulated with approaches of meaningful and autonomous learning, more participatory and effective environments are achieved (Banfield & Wilkerson, 2014; Elles & Gutiérrez, 2021). In these cases, gamification ceases to be an intuitive practice to become a conscious didactic strategy, where the teacher assumes the role of designer of learning experiences rather than a transmitter of content.

Likewise, teachers who receive formal training in gamification develop a more analytical understanding of how game elements can enhance motivation, collaboration, and critical thinking in mathematics. Training, then, not only expands theoretical knowledge but also strengthens the technical skills and professional confidence necessary to integrate digital resources and interactive environments into daily practice. In this sense, teacher training becomes the bridge between innovative intention and real transformation of teaching.

Although studies on teacher attitude towards gamification are still scarce (Martí et al., 2016), existing research shows a positive trend towards its use in the classroom. Claros et al. (2020) point out that many university professors express a favorable disposition to integrate playful elements into their classes, recognizing their potential to dynamize teaching and strengthen the pedagogical bond with students. In the same line, Sagnier et al. (2020) highlight that the proactive attitude of the teaching staff becomes an effective means to incorporate innovations, as those who positively value gamification tend to explore and adapt it more frequently.

In the Bogotá context, Criollo (2023) emphasizes that gamified strategies in mathematics elevate student motivation and commitment, generating more attractive and participatory learning environments. These findings suggest that teacher attitude acts as a catalyst for educational change; when teachers believe in the pedagogical value of innovation, teaching transforms. However, this individual disposition requires institutional support and formative accompaniment to consolidate as a sustainable practice within school culture.

Most studies agree that teachers perceive gamification as an innovative strategy capable of increasing student motivation and commitment. Its potential to transform the classroom into a more dynamic and participatory space makes it a valuable tool for reducing mathematical anxiety and fostering participation. However, these positive attitudes often coexist with concerns and resistances related to its practical application. Tafur et al. (2023) warn that many teachers who use gamification do not fully understand the elements that structure it, which limits its impact on teaching and learning processes.

Likewise, Cunza et al. (2020) found that teachers with greater affinity for games often also show greater apprehension towards their implementation, fearing that the playful component may displace curricular content or trivialize mathematical learning. These tensions reflect a central challenge: achieving a balance between the playful dimension and academic rigor, so that gamification is not perceived as a distraction but as an opportunity to rethink the relationship between emotion, knwledge, and motivation in mathematics teaching.

Another aspect to consider in the adoption of gamification has to do with the material and organiza-

tional conditions that teachers face. Designing gamified experiences requires time, creativity, and resources, which represents a significant challenge for those working with extensive workloads or in institutions with limited technological infrastructure. The lack of access to adequate digital tools and scarce institutional training in the use of interactive platforms not only restricts the possibilities of innovation but also affects teachers' attitudes, generating frustration and demotivation towards the implementation of these strategies. In contrast, teachers who have achieved successful gamification experiences report highly favorable attitudes, accompanied by improvements in academic performance, student collaboration, and classroom climate. These cases show that perceived self-efficacy, understood as the teacher's confidence in their ability to successfully integrate gamification, becomes a determining predictor of the disposition towards pedagogical change. When the teacher recognizes themselves as an agent of transformation, gamification ceases to be an external technique and becomes a meaningful practice that enhances learning and creativity.

Institutional challenges and formative projections

Favorable attitudes toward gamification lose strength when confronted with institutional contexts not conducive to innovation. The implementation of playful strategies in mathematics teaching does not depend solely on the enthusiasm or individual preparation of the teacher, but on a network of internal and external factors that determine its viability. Among the internal factors are training, self-efficacy, and pedagogical beliefs; among the external ones, technological resources, administrative support, curricular alignment, and the socioeconomic conditions of the students. In this sense, gamification cannot be understood only as a methodology, but as an indicator of the tensions and possibilities of the educational system; its success or failure reveals to what extent the school is willing to reinvent itself to respond to the challenges of contemporary education.

The identified challenges reflect a reality shared by numerous educational institutions in Bogotá, where teacher training and the availability of technological resources remain critical factors for pedagogical innovation. Insufficient specific training in designing gamified experiences, added to deficient curricular integration, limits the effectiveness of this methodology and prevents its benefits from consolidating over time (Céspedes, 2022). To this are added persistent problems such as high failure rates in mathematics and low student motivation, evidenced by Castaño and Vargas (2020), who warn that interest in learning decreases when pedagogical strategies fail to connect with the realities and languages of the students.

The scarcity of technological resources, connectivity difficulties, and the lack of institutional support worsen this panorama, especially in vulnerable contexts. These factors not only restrict innovation but also deepen educational inequalities, reproducing the distance between transformation discourses and real possibilities for action in the classroom.

The identified limitations should not be understood solely as obstacles, but also as opportunities for pedagogical and technological innovation. The implementation of gamification in mathematics teaching offers a fertile field to rethink teaching practice, provided teachers receive adequate training and equitable access to necessary resources. With appropriate institutional support, teachers can become pioneers of educational change, developing models and good practices that benefit the entire school community.

Collaboration between universities, educational authorities, and school institutions is essential to build continuous training programs and contextualized pedagogical materials. However, this purpose re-

quires sustained investment in technological infrastructure and teacher training, ensuring the participation of all teachers, regardless of the type of institution or its geographical location. Only in this way will it be possible for gamification to cease being an isolated experience and consolidate as a systematic strategy of educational innovation, capable of transforming teaching and learning dynamics in Bogotá's public classrooms.

Strengthening teacher training in gamification requires going beyond simple technical training. It is about rethinking educational policies and institutional environments so that innovation does not depend solely on individual enthusiasm, but on a school culture that sustains it. Investment in technological infrastructure must be accompanied by continuous and collaborative formative processes, where teachers can design meaningful experiences and reflect on their practice. Only in contexts that articulate support, training, and a shared pedagogical vision can gamification consolidate as a sustainable strategy for educational transformation, capable of humanizing mathematics teaching and contributing to more equitable and creative education in Bogotá.

Specialized literature points out that there is no single definition of gamification, but a wide diversity of interpretations that reflect its conceptual evolution and adaptation to different educational contexts (Lozada & Betancurt, 2015). Beyond its technical nature, gamification is based on constructivist and connectivist principles, which conceive learning as an active, social process mediated by interaction. From this perspective, its efficacy lies not only in playful or technological elements, but in its capacity to stimulate motivation, favor meaningful participation, and generate environments where error is assumed as part of the learning process.

Its psychological foundations centered on motivation, autonomy, self-efficacy, and applied game design models in education allow us to understand why gamification works, not as a methodological adornment, but as a strategy that re-signifies the meaning of learning. Training teachers in this area involves preparing them to create activities adapted to curricular objectives and the characteristics of their students, where game mechanics, dynamics, and components align with clear learning purposes. Designs of this type allow students to develop numerical thinking and problem-solving in interactive and challenging environments (Becerra et al., 2023). Along the same lines, Cárdenas and Chacón (2023) propose the implementation of gamified mathematical challenges as a strategy to strengthen student motivation, autonomy, and participation, demonstrating that pedagogical creativity can transform traditional teaching into a meaningful and collaborative experience.

The use of technological tools and platforms represents an essential component in teacher training for the implementation of gamification. It is not just about learning to use software or applications, but understanding how these resources can be integrated in a meaningful and contextualized manner into teaching and learning processes. In this regard, the Ministerio de Educación Nacional (2018) has promoted spaces like the Colombia 4.0 workshop in Bogotá, where 80 preschool, elementary, and high school teachers were trained in the use of gamified tools from the educational portal *Colombia Aprende*.

Complementarily, universities in the country have developed projects aimed at strengthening teachers' technological competencies through immersive gamified experiences. The Universidad de Santander (2025), for example, promotes an innovative methodology that accompanies real pedagogical practice, considering the institutional and community contexts of the teachers. These initiatives show that technological adoption cannot be reduced to instrumental mastery; it must be understood as a com-

prehensive formative experience, where technology is put at the service of creativity, collaboration, and educational transformation.

The evaluation of gamification constitutes a central challenge in educational innovation processes. Training teachers in this competence involves teaching them to assess the effectiveness of gamified strategies not only based on academic results, but also considering indicators of student motivation, participation, and commitment. Although in Colombia there have not yet been specific studies on teacher evaluation of gamified strategies in mathematics, previous research offers relevant conceptual foundations (Mera, 2016; Cáceres & Gómez, 2022; Cárdenas & Chacón, 2023).

This research agrees that evaluation should be conceived as a formative and reflective process, allowing the teacher to analyze not only what students learned, but how they learned it and what emotions, decisions, and cognitive strategies were involved in that learning. In this sense, evaluating gamification involves rethinking the criteria of educational success, incorporating affective and collaborative dimensions that transcend traditional grading and consolidate a more human, participatory, and meaningful mathematics teaching.

To overcome the identified barriers and fully harness the potential of gamification in mathematics teaching in Bogotá, it is necessary to move towards comprehensive actions involving both educational policymakers and practicing teachers. It is not only about incorporating technological tools or game dynamics, but reconfiguring the institutional, formative, and cultural conditions that allow gamification to consolidate as a sustainable pedagogical strategy, capable of transforming the teaching and learning of mathematics in the city's public schools.

Ensuring that all educational institutions in Bogotá, especially public ones, have adequate technological infrastructure is an indispensable condition for implementing gamified strategies. This includes equitable access to connectivity, updated devices and educational software, as well as safe and sustainable digital environments. According to the Ministerio de Educación Nacional (2025), "educational infrastructure not only supports the teaching-learning process, but also plays a crucial role in creating an inclusive, motivating, and healthy environment for the entire educational community."

In line with this, the regional convergence strategic line of the National Development Plan 2022–2026 emphasizes the need to "promote territorial equity and overcome gaps in access to education from preschool to higher education" (Findeter, 2023). This vision reinforces the principle that pedagogical innovation, and particularly gamification, cannot consolidate without material conditions guaranteeing universal access to technology as a tool for learning and educational justice.

It is essential to promote the creation, dissemination, and use of Open Educational Resources (OER) specifically designed for the Colombian mathematics curriculum. These materials can include digital platforms, educational games, design templates, pedagogical guides, and collaborative repositories that facilitate adaptation by teachers to different levels and school contexts. Besides promoting methodological innovation, OERs contribute to democratizing access to knowledge and strengthening teacher autonomy, allowing teachers to share, modify, and improve materials according to their students' needs. Their development requires joint work between universities, ministries, and teacher communities, ensuring these resources are free, accessible, and culturally relevant, in coherence with an

open and equitable public education.

It is indispensable to incorporate gamification as a structural component in initial and continuous training programs for mathematics teachers. In this way, future educators can develop pedagogical and technological competencies that allow them to apply active methodologies from the start of their professional practice. As stated by Lozada and Betancur (2015), "the constant need to update educational methods must be considered to improve the quality of education, which depends mainly on the content taught, the needs of society, and coverage." From this perspective, teacher training must go beyond technical updating; it implies rethinking teaching as a space for creativity, autonomy, and commitment to innovation, where gamification becomes a key tool for connecting mathematical learning with the realities and motivations of students.

It is fundamental to promote action-research as a permanent practice among mathematics teachers, allowing them to analyze, evaluate, and improve the effectiveness of gamification in their own contexts. This approach turns the classroom into a pedagogical laboratory, where reflection on practice generates situated knowledge relevant to the educational realities of Bogotá. Besides strengthening professional autonomy, action-research promotes a collaborative and critical teaching culture, in which educators not only apply innovative methodologies but also construct and validate their own pedagogical knowledge, thus contributing to the development of more contextualized, participatory, and sustainable education.

Methodology

This reflection is framed within an analytical and critical review related to gamification in mathematics teaching and teacher attitudes towards its implementation. The work is based on a process of theoretical review, but approached from an interpretive perspective, focused on understanding how previous studies have explained the relationship between pedagogical innovation, teacher training, and educational practice. More than applying a meta-analysis protocol, the interest lay in identifying the main debates, tensions, and gaps present in the literature, to contribute a contextualized reading of the phenomenon within the framework of mathematics education in Bogotá.

For the development of this reflection, an exhaustive documentary review was carried out aimed at recognizing advances, challenges, and contemporary approaches regarding gamification in mathematics teaching. Recent and representative studies from both the international sphere and the Latin American context were prioritized, to articulate global perspectives with the educational particularities of Bogotá. This analysis allowed building a solid theoretical base that supports the reflection and accounts for the main debates surrounding the incorporation of active methodologies in mathematics education.

In addition to reviewing specialized academic sources, a process of contrasting and dialoguing between different theoretical perspectives was carried out, with the purpose of broadening the understanding of the phenomenon and avoiding a fragmented view of gamification. This exercise allowed identifying coincidences, tensions, and conceptual gaps in studies on mathematics education, as well as recognizing the most recent approaches to teacher training and attitudes towards innovation. The articulation between classical authors and contemporary contributions enriched the analysis, offering an integral vision that combines theoretical foundations, classroom experiences, and pedagogical reflections.

The selection of literature supporting this reflection was based on conceptual and pedagogical criteria rather than procedural ones. Those studies that offered significant contributions on teacher knowledge, attitudes, and perceptions regarding gamification and its relationship with mathematics teaching were prioritized. Likewise,

research that addressed educational innovation from qualitative, quantitative, or mixed approaches, contributing to understanding the human and contextual dimension of pedagogical practice, was considered.

Both scientific articles and book chapters, as well as documented experiences and case studies that allowed contrasting international perspectives with Latin American realities, were included. The selection responded to criteria of relevance and timeliness, rather than exhaustiveness, with the purpose of constructing a critical and situated vision of the analyzed educational phenomenon.

Similarly, the analysis process involved an intentional delimitation of the focus, avoiding the inclusion of studies that did not directly address mathematics teaching or the teacher's role regarding gamification. Works focused exclusively on student learning or game experiences disconnected from pedagogical analysis were discarded. This decision allowed maintaining the thematic and epistemological coherence of the reflection, focusing it on teaching practice as a privileged space for understanding the reach and limitations of gamification in the classroom.

Likewise, priority was given to academic texts with scientific backing, excluding dissemination materials or proposals without research foundation. This selection did not seek to restrict debate, but to preserve the rigor and pertinence of the analysis, ensuring that the sources provided evidence or solid arguments about the examined educational phenomenon.

The analysis process was developed in several interpretive stages that allowed organizing and understanding the information from a critical perspective. First, an identification of predominant approaches in recent literature on gamification and mathematics teaching was carried out, recognizing the contexts where this strategy has had greater development and the factors that have limited its adoption.

Subsequently, an analytical and comparative reading of the selected studies was undertaken, with the purpose of identifying convergences, contradictions, and conceptual gaps. This phase focused on reconstructing the educational discourse that has been configured around the teacher's role, making visible how attitudes, knowledge, and beliefs influence the implementation of gamification.

Finally, the information was synthesized into thematic axes that articulate the reflection presented in this article: gamification as an emerging pedagogical approach, teacher training and attitude towards methodological innovation, and the institutional challenges conditioning its integration in the classroom. This process allowed transcending the description of results and advancing towards an interpretive reading of the educational phenomenon, coherent with the reflective purpose of this work.

Search strategy

The search strategy was designed to identify the most relevant and up-to-date literature in high-impact academic databases. Combinations of keywords in Spanish and English were used, including terms related to 'gamification', 'mathematics', 'teachers', 'attitudes', 'knowledge', 'perception', 'training', and 'education'. The databases consulted were Scopus, Web of Science, ERIC, Scielo, Dialnet, and Google Scholar, selected for their coverage in the field of education and their indexing of quality scientific journals. The search was limited to publications from 2010 to the current date (2025) to ensure the relevance and currency of the studies. The general search string used was as follows:

> (gamificación OR gamification) AND (matemáticas OR mathematics) AND (docentes OR teachers OR professors OR educators) AND (actitudes OR attitudes OR percepción OR perception OR conocimiento OR knowledge OR formación OR training) AND (educación OR education).

In addition to the database search, a manual search was conducted in the reference lists of identified key articles, in institutional repositories, and in specialized journals in mathematics education and gamification to identify additional studies that might not have been captured by the initial search. This search via other methods allowed expanding the scope of the review and ensuring the inclusion of relevant literature.

Eligibility criteria

For the selection of studies, clear and predefined inclusion and exclusion criteria were established:

Inclusion criteria

- **Empirical studies:** Quantitative, qualitative, or mixed-methods works that investigate teachers' knowledge, attitudes, or perceptions regarding gamification in mathematics teaching.
- Publication status: Articles published in peer-reviewed scientific journals, book chapters, or research works (theses) were included.
- **Data:** Studies had to report the author's institutional affiliation.
- **Language:** Study reports had to be available in English or have a partial English translation in which the methods and results were clearly described.
- **Thematic focus and educational level:** Studies that included gamification at any educational level (primary, secondary, higher education) as long as the focus was mathematics teaching.
- **Type and quality of included studies:** Studies that included primary data or systematic reviews that met the quality criteria.

Screening: All identified records were imported into a reference manager to remove duplicates. 200 duplicate records were removed, leaving 1350 records for screening. At this stage, the titles and abstracts of the remaining records were examined to assess their relevance against the inclusion criteria. 1100 records were excluded at this stage for the following main reasons:

- **Reason 1:** Not relevant for gamification in mathematics (n=500): These studies addressed gamification in other areas of knowledge or did not focus on its specific application in mathematics.
- **Reason 2:** Not focused on teachers (n=400): The studies focused on the impact of gamification on students, without analyzing teachers' knowledge, attitudes, or perceptions.
- **Reason 3:** Not an empirical study (n=200): These were theoretical review articles, essays, opinions, or project descriptions without a clear empirical research methodology.

After screening, 250 records remained and proceeded to the next phase.

Eligibility and inclusion: The 250 records selected in the screening phase were retrieved in full text. An attempt was made to retrieve 250 reports, of which 230 were retrieved and 20 could not be retrieved (e.g., restricted access, broken links). The 230 retrieved reports were assessed in full text by two independent reviewers to determine their final eligibility. 170 reports were excluded at this stage for the following reasons:

- **Reason 1: Does not meet inclusion criteria (n=100):** Despite passing the initial screening, the full-text reading revealed they did not meet all inclusion criteria (e.g., not an empirical study, not focused on teachers or mathematics).
- **Reason 2: Incomplete data (n=50):** The study did not provide sufficient information on methodology or results to be included in the analysis.

- **Reason 3:** Unsupported language (n=20): Although Spanish and English were prioritized, some retrieved studies were in other languages not handled by the reviewers.

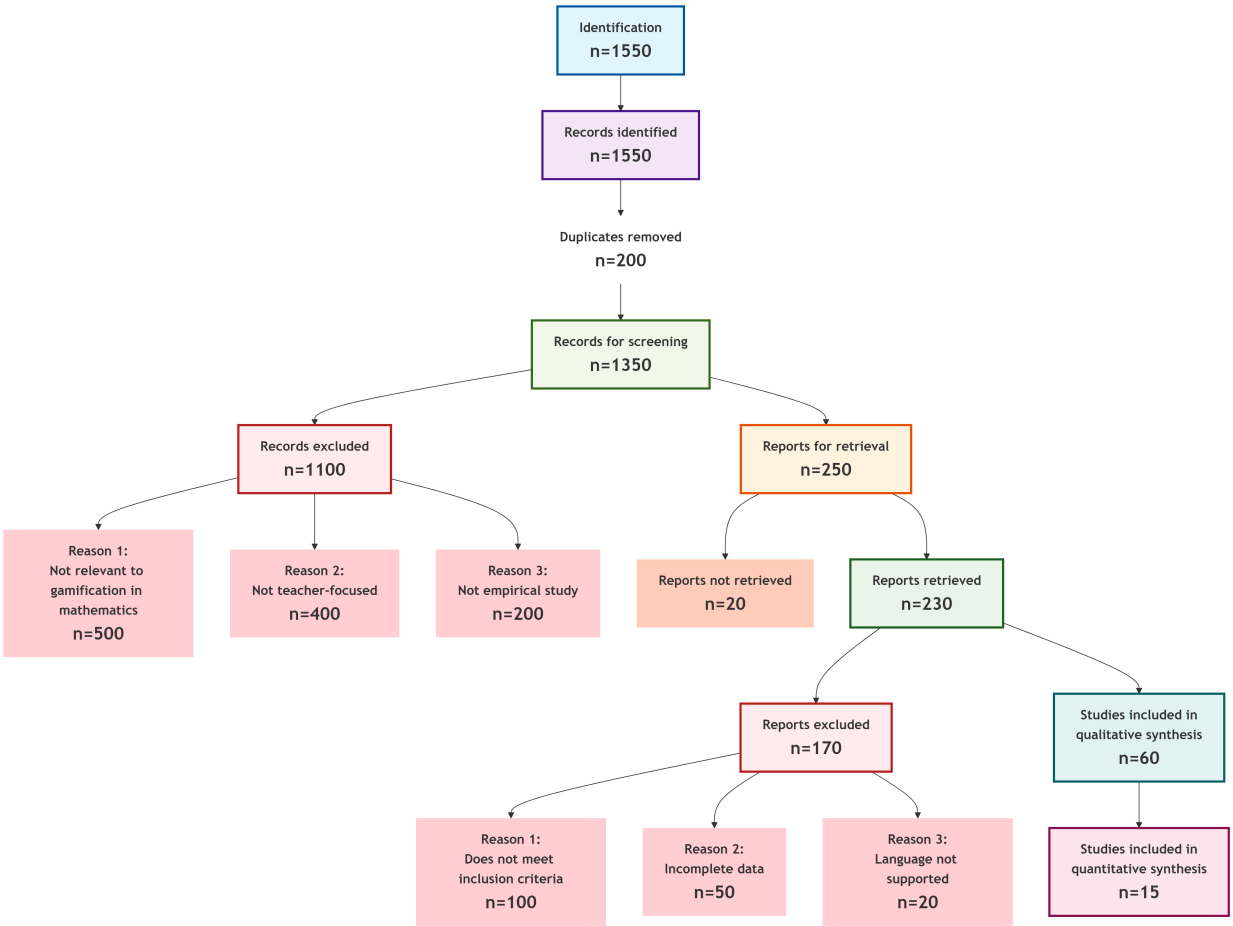
Finally, 60 studies were included in the qualitative synthesis. Of these, 15 studies provided quantitative data allowing their inclusion in a quantitative synthesis (meta-analysis, if applicable, or descriptive analysis of numerical data).

PRISMA Flow Diagram

The study selection process is summarized in the following PRISMA flow diagram (Figure 1):

Figure 1

PRISMA flow diagram of the study selection process



Nota: Elaboración propia (2025).

Data extraction and synthesis

For each included study, the following relevant data were extracted:

- **General information:** Author(s), year of publication, title, type of publication (article, thesis, other).
- **Study characteristics:** Research design (quantitative, qualitative, mixed-methods), population and sample (number of teachers, educational level, geographical location), context (type of institution, specific mathematics area).
- **Variables of interest:** Instruments used to measure knowledge, attitudes, or perceptions about gamification; key results related to these variables.
- **Main findings:** Synthesis of the most relevant results, including perceived strengths and weaknesses of gamification, influencing factors, and recommendations.

Data synthesis was conducted narratively for qualitative findings and descriptively for quantitative data. Studies were grouped according to emerging themes related to teacher knowledge and attitudes, identifying patterns, inconsistencies, and gaps in the literature. Special attention was paid to studies conducted in contexts similar to Bogotá or in Colombia to contextualize the findings. The methodological quality of the included studies was assessed using appropriate critical appraisal tools for each research design type, although the details of this assessment are presented in the Results section.

Results

The systematic literature review, following the PRISMA methodology, allowed for the identification and synthesis of key findings related to mathematics teachers' knowledge and attitudes towards gamification. A total of 60 studies were included in the qualitative synthesis, and of these, 15 provided quantitative data that contributed to a deeper understanding of the variables of interest. The results are presented in three main subsections: Level of teacher knowledge about gamification, teacher attitudes towards gamification, and influencing factors and perceptions of strengths and weaknesses.

Level of teacher knowledge about gamification

The reviewed studies indicate variability in the level of knowledge of mathematics teachers regarding the principles and elements of gamification. While a significant proportion of educators have heard the term or have a basic understanding of its concept, a deep knowledge of game mechanics, dynamics, and components, as proposed by Werbach and Hunter (2012), is less common.

Many teachers primarily associate gamification with the use of points, badges, and leaderboards (PBLs), suggesting a superficial understanding often referred to as "pointification." This limited view can lead to ineffective implementation of gamification, where game elements are added without meaningful pedagogical integration with learning objectives. It is known from international studies that although some teachers are familiar with the term gamification at some point, only a small group is able to correctly identify the different types of players or the underlying motivations that gamification seeks to activate (Palacios and Cimas, 2024).

The lack of specific training in gamification is a recurring factor explaining these knowledge gaps. According to Cáliz, Cerón and Hernández (2024), students who lack the necessary knowledge to handle technological equipment and tools face obstacles in their learning process and the development of digital competencies. This lack of knowledge creates a gap among students. Gamification offers a possible solution by providing an innovative approach that integrates game elements to facilitate learning processes and acquire new knowledge that improves students' academic performance.

Positive results in students are related to precise instructions for the development of applied activities, in a dynamic, diverse, and harmonious manner, through pedagogy, didactics, and gamification strategies, with designs that incorporate meaningful and autonomous learning (Banfield and Wilkerson, 2014; Elles and Gutiérrez, 2021). Likewise, when teachers receive formal training in the design and implementation of gamified strategies, they demonstrate significantly greater knowledge and a more nuanced understanding of how gamification can be used to enhance mathematics learning. In this way, training not only improves familiarity with theoretical concepts but also equips teachers with the technical skills necessary to integrate digital tools and gamified platforms into their practices.

Teacher attitudes towards gamification

There are few studies concerning teacher attitudes towards gamification in educational institutions (Martí, et al. 2016). However, there is a positive attitude among university teachers regarding the use of gamification in their classes (Claros, et al. 2020). It is known that teachers having an inclination towards using gamification and perceptions towards such innovations constitutes an effective means in teaching (Sagnier et al., 2020). Similarly, Criollo (2023) has mentioned that a gamified strategy in mathematics elevates student motivation and commitment, energizes the classroom environment, and makes content more attractive, in the Bogotá context. These nuances occur because teacher attitudes are positive.

Most studies indicate that educators perceive gamification as an innovative strategy with the potential to increase student motivation and commitment. Its capacity to transform the classroom into a more dynamic and attractive environment is valued, which can reduce mathematical anxiety and improve student participation. However, these positive attitudes often coexist with concerns and resistance. Some studies (Tafur et al. 2023) argue that teachers who use gamification do not always understand the elements that constitute it, which affects the teaching-learning process to some extent. Research has found that teachers with greater affinity for games show more concern about its application in the classroom compared to those with less affinity (Cunza et al. 2020). Hence the perception that gamification may divert focus from essential curricular content or trivialize mathematics learning.

Another relevant aspect is that designing effective gamified experiences requires time, creativity, and resources, which can be a challenge for teachers with tight schedules and limited resources. The lack of access to adequate digital tools or insufficient technological infrastructure in educational institutions also negatively influences teacher attitudes, generating frustration and demotivation to adopt these strategies.

In contrast, teachers who have experienced success with gamification in their classrooms report very favorable attitudes, highlighting improvements in academic performance, student collaboration, and the overall classroom atmosphere. Perceived self-efficacy, i.e., the teacher's confidence in their ability to successfully implement gamification, is a significant predictor of positive attitudes and the willingness to integrate this methodology into their practices.

Influencing factors and perceptions of strengths and weaknesses

The implementation of gamification in mathematics teaching is influenced by a variety of factors, both internal (related to the teacher) and external (related to the educational context). The reviewed studies identify the following key factors:

Internal factors

- **Prior training level:** It has already been indicated above that specific training is fundamental

for deep knowledge and positive attitudes when implementing gamification in mathematics teaching. Indeed, research conducted (Ponce, 2024) confirms that the fact that gamification is not carried out in different institutions has to do with teacher training, but also with the availability of resources and institutional support. Likewise, the incorporation of digital tools depends on teachers' digital skills and competencies (Rojas and Gallesse, 2025). However, its implementation faces several challenges, including structural limitations, lack of time, knowledge and skills on the part of teachers, and difficulties in designing effective and creative gamified activities (Quimí et al. 2024).

- **Teaching experience:** Teachers with more years of experience may show greater resistance to change, while younger or less experienced teachers may be more open to innovation (Guillén, 2025).
- **Perceived self-efficacy:** Confidence in one's own abilities to design and implement gamification is a strong predictor of its adoption. Indeed, studies conducted by Perochena et al (2020) indicate that the capacity to innovate and incorporate changes, and satisfaction with one's own work, are closely linked to self-efficacy.
- **Pedagogical beliefs:** Teachers' teaching philosophies influence their openness to active and playful methodologies. But they are also linked to their attitudes towards the use of communication technologies (Letwinsky, 2017; OECD, 2019b).

External factors

- **Resource availability and institutional support:** Access to technology, gamified platforms, and teaching materials is fundamental. However, the support of school administration, the availability of time for planning and training, and the recognition of innovation are important. In this vein, research focused on rural gamification in the Bananera zone (Magdalena) concludes that, although teachers see its potential, many face resource and time limitations for planning. This excessive demand can prevent a deep and sustained pedagogical implementation (Ponce, 2024).
- **Curricular alignment:** The perception that gamification can be integrated coherently with the objectives and content of the mathematics curriculum is vital for its sustained adoption. The work of Ponce (2025) emphasizes that strategic planning is the cornerstone for incorporating gamification in correspondence with educational objectives, competency standards, and subject area plans. This shows that it is not enough to introduce playful elements; they must be designed with pedagogical coherence in mind to have a real impact on learning.
- **Socioeconomic context:** The socioeconomic conditions of students and the institution can influence the viability and type of gamified strategies to be implemented. According to research by García (2025) the mere provision of technology is not sufficient to address digital competencies. Adequate pedagogical support and the implementation of inclusive and equitable educational policies are required. It must be taken into account that "only 51.9 percent of households at the national level in Colombia have access to the Internet" (Departamento Administrativo Nacional de Estadística de Colombia, 2020).

Regarding perceptions about the strengths of gamification in the mathematics classroom, teachers consistently highlight:

- **Increased motivation and commitment:** Gamification makes learning more fun and attractive, which translates into greater student participation. Gamification generates positive changes in student behavior and attitude, the process becomes pleasant and motivates knowledge appro-

priation (Mera, 2016). Experiences conducted with students from schools in Popayán confirm that 98% of 340 participants feel motivated and the applications used by teachers have allowed them to easily understand the content (Santa María, 2011 cited by Mera, 2016). Similarly, it has been achieved in international studies conducted in Spain (Cáceres and Gómez, 2022) that play elevates student motivation.

- **Improved academic performance:** The results obtained by performance levels in mathematics in the "Saber 11" tests in 2024-2 in the country's schools and published by the Colombian Institute for Educational Evaluation (Icfes, 2025) reveal the following:

Table 1

Schools in Bogotá by performance levels in mathematics in the "Saber 11" tests in 2024-2

Range by level	Institutions	Sections	Evaluated	% Eval.	Weighted average
<35	1	1	1	0,00	31,00
36-51	221	376	15.853	20,43	47,91
51-70	852	1026	59.845	77,11	56,96
>71	38	39	1.915	2,47	73,68
Total general	1112	1442	77.614	100,00%	55,53

Note: Prepared by the author with data from Icfes 2024-1.

The results show that 20.43% of the students (15,853) are placed at Level 2, which indicates that the students read specific information (a piece of data, for example) related to everyday situations and presented in tables or graphs with an explicit scale, grid, or at least horizontal lines. Furthermore, they demonstrate that:

> (a) They compare data from two variables represented in the same graph without needing to perform arithmetic operations. (b) They identify representative values or points in different types of records based on the meaning they have in the situation. (c) They compare the probability of simple events (favorable cases/possible cases) when the possible cases are the same in both events and in contexts similar to those presented in the classroom. (d) They make decisions about the truthfulness or falsity of a statement when it can be explained by verbalizing the direct reading made of the information. (e) They change bar graphs to double-entry tables. (f) They recognize and interpret, according to the context, the meaning of simple average, mode, greater, lesser, maximum, and minimum. These students come from approximately 221 schools (Icfes, 2025, p. 3).

The majority of students (77.11% or 59,845) are concentrated at Level 3. These results, representing 852 institutions, point to traditional teaching centered on mechanical exercises more than on critical thinking. Icfes notes that these students need to strengthen the application of concepts in real contexts, through technological tools and problems linked to their environment. These results suggest that in addition to the domains of Levels 1 and 2, the students know how to:

> a) Select the graph (which can be a double-entry graph corresponding to the information in a table, or based on verbalizations (desired growth or growth characteristics), taking into account

> for the selection the scale, the type of variable, and the type of graph. (b) Compare graphic information that requires some arithmetic manipulations. (c) Point out information represented in non-conventional formats (maps or infographics). (d) Recognize errors that occurred when performing a transformation between different types of records. (e) Recognize flat developments of a three-dimensional shape and vice versa. (f) Compare the probability of simple events in various contexts (favorable cases/possible cases), even when the possible cases of each event are different. (g) Select information necessary to solve problems involving arithmetic operations. (h) Select information necessary to solve problems involving measurable characteristics of elementary geometric figures (triangles, quadrilaterals, and circles). (i) They change the scale when the transformation is not conventional. (j) Justify statements using approaches and arithmetic operations or by making direct use of a concept, that is, based on a single argument. (k) Identify relevant information when the type of record contains information from more than three categories. (l) Perform simple algebraic manipulations (arithmetic of like terms) that are basic, but with limitations in skills such as graph interpretation and abstract reasoning (Icfes, 2025, p. 4).

Finally, only 2.47% (1,915 students) reach the Advanced Level, demonstrating excellent performance in mathematical modeling and argumentation. These cases, present in around 38 schools, are usually associated with institutions with innovative programs, use of educational technologies, and cross-curricular projects. The gap between these schools and those with low results evidences inequalities in resources and methodologies, which demands policies to share good practices and reduce disparities in educational quality. The indicators indicate the following about this level:

> The evaluated person who is placed at Level 4, in addition to what is described in Levels 1, 2, and 3, demonstrates that: (a) They solve problems that require interpreting information from dependent events. (b) They perform transformations of subsets of information that may require the use of complex operations (percentage calculations). (c) They solve problems that require constructing an auxiliary representation (graphs and formulas) as an intermediate step for their solution. (d) They model using algebraic language information given in natural language, tables, or geometric representations. (e) They manipulate algebraic or arithmetic expressions using the properties of operations. (f) They model non-explicit variational phenomena using symbolic language or graphs. (g) They recognize in different formats (trees, lists, or diagrams) the sample space of a random experiment. (h) They solve counting problems that require the use of permutations. (i) They justify whether there is a lack of information in a problem situation to make a decision. (j) They make decisions about the truthfulness or falsity of a statement when it requires the use of several properties or formal conceptualizations (Icfes, 2025, p. 5).

Finally, it should be noted that the results of the Saber 11 tests indicate that the vast majority of students have Insufficient or Minimal performance in mathematics, evidencing difficulties in motivation and meaningful learning. Gamification emerges as a key pedagogical strategy by transforming content into interactive challenges, encouraging participation and the development of competencies, as already indicated in this article and substantiated by different studies. By integrating game mechanics (levels, rewards, and immediate feedback), it could improve performance in the most critical groups while consolidating skills at advanced levels in learning mathematical concepts and problem-solving. Likewise, gamification is an innovative strategy for teaching mathematics to fourth-grade students in Bogotá, which makes learning dynamic (Molina, 2024). Other international studies confirm that gamification in educational contexts favors student participation, motivation, and academic performance (Ayala et al., 2022; Deterding et al., 2011; Hamari et al., 2014, Hanus and Fo, 2015).

- **Development of soft skills:** It fosters collaboration, critical thinking, creativity, and resilience in the face of failure. Applications like Classcraft allow the design of gamifiable and workable activities in the classroom and it works because it drives the student less captivated in the area of mathematics, increases motivation as they succeed in the game, the system of risks and rewards is an ally for acquiring knowledge in progress, fosters collaboration and cooperation among peers. In the teaching-learning process, students know at all times what their objectives are and strive to achieve them. It generates healthy competitiveness among students. Student behavior in the classroom improves notably in attitude and in the apprehension of knowledge (Elles, 2020). Research has shown that the use of gamified applications helps achieve competence to pose and solve problems that comprise the translation of real situations into mathematical schemes/models and problem-solving using appropriate strategies, performing mathematical operations without the help of other instruments, fosters teamwork allowing students to share ideas and develop their interpersonal skills (Holguin et al. 2020). Likewise, through gamification, students have fun while learning and improve their knowledge in a meaningful way for their school development (Pérez, 2025). Similarly, gamification strengthens social skills (Calabor et al., 2018), allows students to develop their skills and enhance the teaching-learning process (Ortiz and Guevara, 2021).
- **Immediate feedback:** Game elements allow students to receive instant feedback on their progress, which facilitates self-regulated learning. Some studies confirm that the more gamification increases in its elements and formative assessment in the digital context, the more mathematics learning changes significantly (Prada, et al., 2021).

On the other hand, the perceived weaknesses include the following (see Figure 2):

Figure 2

Perceived weaknesses

Note: Own elaboration (2025).

- **Lack of training and knowledge:** This is perhaps the main barrier to effective implementation; it hinders the ability to promote the development of logical-mathematical competencies in students (Gutiérrez, 2023). Other research reveals that teachers do not address the central aspects of gamification because they have weaknesses, which makes it difficult for them to generate changes in pedagogical practices and apply gamification (Mosquera and Londoño, 2022).

Among those weaknesses found are knowledge in design and implementation; studies (Wiggins, 2016) reveal that this is perhaps the greatest barrier affecting teachers when designing and implementing gamification, leading to low interest in carrying out didactic strategies in the classroom. The same happens with little knowledge of resources, which causes the applied gamified strategies to be inappropriate for the student's age or cognitive level (Canhoto and Murphy, 2016). Another aspect to note is that students must learn to apply their knowledge, to improve their socio-communicative skills (Teichler, 2007).

- **Difficulties in curricular integration:** In mathematics, difficulties persist such that "school failure and even abandonment, it is necessary to recognize different didactic approaches that invite motivation and focus the learner's attention on a syllabus linked to a laborious comprehension" (Castro, 2021, p. 21). Precisely, this situation represents a challenge of implementing gamification with learning objectives and the curriculum without it being perceived as an isolated activity. Studies conducted in Colombia confirm that the use of gamification as a methodological and didactic tool encourages student participation and interest towards mathematics and enhances the pedagogical praxis of the teacher in the classroom (Casalla and Mahecha, 2019). In turn, gamification is an innovative tool that enables and facilitates the understanding of knowledge by students; as well as establishing a challenge for the teacher to explore and integrate other methods and pedagogical resources in their classes (Sánchez, 2018).
- **Limited resources:** Although the "Colombia Aprende" Program (2009) of the National Ministry of Education has provided multiple technological tools for teachers and students for the development of competencies in problem-solving, reasoning related to posing hypotheses and problems, making conjectures, exploring examples using self-learning, directed learning, or instruction. These efforts have not been enough; the lack of access to technology, software, or specific materials can hinder implementation. It is known that the insufficiency in the quantity of devices to ensure that all students can interact with the gamified strategy is related to the lack of computers or alternative technological devices like cell phones or tablets (Piñeiro and Costa, 2015). But also, some of the free versions of certain online games or gamified platforms for education and the decrease in internet access correspond to obsolete technologies (Valencia and Orellana, 2019).

It is undeniable that in Colombia, as in most Latin American and Caribbean countries, there are problems of coverage, infrastructure, inadequate teacher training, as well as social and economic gaps, inappropriate teaching strategies, inequality in internet access while stratum six has 99.8%, for stratum one it is only 20.5%. 21.7 million have internet access and 23.8% do not. In reality, those most affected are poor families in neighborhoods and rural areas of the country (Murcia, 2023; Tamayo et al. 2015).

Impact of gamification on academic performance and motivation

Although the main focus of this study is teacher knowledge and attitudes, the reviewed works also provide evidence on the impact of gamification on students' academic performance and motivation, aspects that directly influence teachers' perception and disposition. Most empirical research reports a positive effect of gamification on student motivation towards mathematics. It is found that the application of gamification strategies produces significant advancement of most students regarding the concept of fractions, terms, operations (addition, subtraction, multiplication, and division) and the solution of mathematical problems (Niampira, 2023).

It is worth noting that educational experiences carried out in schools in Bogotá have developed intervention strategies focused on video games/gamification with Scratch to strengthen geometry lear-

ning (Hernández and Sarmiento, 2022). Other experiences have referred to the design of gamified virtual learning environments with missions and challenges to teach fractions to seventh-grade students. These situations generate changes in student attitudes that translate into better academic performance and motivation to learn since they contain elements typical of problem-solving, such as the assignment of a development context and the structuring of phases of diagnosis, feedback, and evaluation (Aldana, 2020).

Likewise, the implementation of a virtual learning environment has generated positive impacts on students, improving the competency of problem posing and solving, the numerical-variational component, and the geometric-metric component; although it is recognized that most students obtained a basic performance. Not all students appropriated the steps to solve the proposed problems. The students showed interest in the digital tools used in the virtual learning environment and interacted without difficulties in each of the sections, and most solved the proposed activities in it. Similarly, the use of gamified strategies in basic mathematics (such as addition, subtraction, place value), incorporating elements such as missions, scores, and digital rewards motivate students in the development of exercises like additions, division (divisibility criteria), multiplication, and subtraction (Castillo, 2021). These and other works indicate that a significant proportion of studies suggests that gamification can improve learning outcomes in mathematics and incorporate elements such as immediate feedback through playful interactions, which facilitates the understanding of mathematical content by presenting it in a clearer and more attractive way. On the other hand, gamification can foster a collaborative learning environment, where students work together to overcome challenges, which in turn improves their communication and problem-solving skills. However, studies by García (2021) mention that poor design planning or lack of teacher integration affects the result, that is, the simple adoption of playful elements does not guarantee progress if there is no pedagogical structure. In this sense, as affirmed by Rodríguez and Visbal (2022), changes are required in the design of didactic strategies to gamified strategies that allow understanding and enhancing knowledge in students. This reinforces the importance of teacher training not only in the technical aspects of gamification but also in its effective pedagogical application.

Challenges and opportunities in the context of Bogotá

The identified challenges are similar to those of many educational institutions in the city, where the availability of teacher training and technological resources is often a critical factor. Just like insufficient teacher training, deficient integration into the curriculum that limits the effectiveness of gamification, the number of failures in mathematics, low motivation to learn (Castaño and Vargas, 2020), scarcity of technological resources and connectivity difficulties, lack of teacher preparation to plan adequate gamified experiences (Céspedes, 2022).

These presented situations represent the opportunity to innovate from the pedagogical and technological implementation in the classroom, provided that resources are provided and teachers are adequately trained, which would represent the opportunity to turn mathematics teachers into pioneers in the implementation of gamification, creating models and good practices that benefit the entire educational community. Collaboration between academia, educational authorities, and schools is fundamental to developing training programs and resources that are relevant and accessible to teachers in the city. However, to achieve these things, investment in technological infrastructure and training programs is required to ensure that all teachers, regardless of their location or the type of institution they work in, have the opportunity to acquire the necessary skills and knowledge to implement gamification effectively.

Implications for teacher training in Bogotá

The findings of this systematic review have direct and significant implications for the design and implementation of teacher training programs in Bogotá. It is evident that current training is not sufficient to equip mathematics teachers with the knowledge and skills necessary for the effective implementation of gamification. Professional development programs must go beyond introductory workshops and offer more in-depth courses that address:

- **Theoretical foundations of gamification:** The literature reviewed in this article makes it clear that not only is there a wide diversity of definitions about what gamification is, but there is no universal definition (Lozada and Betancurt, 2015). Furthermore, the epistemological bases of gamification lie in constructivism and connectivism. So, not only what gamification is, but why it works, its psychological bases (intrinsic vs. extrinsic motivation) and applied game design models in education.
- **Pedagogical design of gamified experiences:** Train teachers so they can design their own gamified activities, adapted to the specific learning objectives of the mathematics curriculum and the characteristics of their students. This includes the appropriate selection of mechanics, dynamics, and game components, as well as the creation of attractive narratives and meaningful challenges. The design of resources to strengthen students' numerical thinking by offering interactive spaces strengthens students' numerical thinking (Becerra et al., 2023). Design and implementation of a set of activities oriented towards the gamification of mathematical challenges (Cárdenas and Chacón, 2023).
- **Use of technological tools and platforms:** Provide practical training in the use of software, applications, and platforms that facilitate the implementation of gamification, considering the diversity of resources available in educational institutions in Bogotá. From this perspective, the National Ministry of Education conducted a workshop in Colombia 4.0 in Bogotá, training 80 preschool, elementary, and middle school teachers in the use of gamified tools available on the educational portal *Colombia Aprende* (Miniserio d Educación Nacional, 2018). Furthermore, in some universities, projects are being developed such as an innovative methodology to strengthen teachers' technological competencies through immersive gamified experiences. This project seeks to accompany the real pedagogical practice of teachers, considering the institutional and community context, with the purpose of promoting a solid and meaningful integration of emerging technologies (University of Santander, 2025).
- **Evaluation of gamification:** Teach teachers how to evaluate the effectiveness of their gamified strategies, both in terms of student motivation and engagement and academic performance in mathematics. Although no specific studies were identified in Colombia that teach teachers to evaluate the effectiveness of gamified strategies in mathematics in terms of motivation, engagement, and performance, there is research that can serve as a conceptual basis as already indicated in this systematic review (Mera, 2016; Cáceres and Gómez, 2022; Cárdenas and Chacón, 2023).

Furthermore, training must be continuous and accompanied by classroom follow-up and support. The creation of communities of practice among mathematics teachers implementing gamification can be an effective strategy to foster collaborative learning, experience sharing, and joint problem-solving. Universities and education secretariats in Bogotá have a fundamental role in articulating these training programs, ensuring they are relevant, accessible, and of high quality. But it is "necessary to continue researching the attitudes of mathematics teachers regarding the potential of game-based learning and gamification in teaching the subject" (Palacios and Cimas 2024, p. 3).

Recommendations for educational policies and practice in Bogotá

To overcome the identified barriers and maximize the potential of gamification in mathematics teaching in Bogotá, the following recommendations are proposed, aimed at educational policymakers and teaching practice:

- **Investment in technological infrastructure:** Ensure that all educational institutions in Bogotá, especially public ones, have access to adequate technological infrastructure (internet connectivity, devices, software) that allows for the smooth implementation of gamified strategies. Currently, there is an ongoing investment plan for improving infrastructure in educational institutions. Ministerio de Educación Nacional (2025, para. 1) "Educational infrastructure not only supports the teaching-learning process, but also plays a crucial role in creating an inclusive, motivating, and healthy environment for all members of the educational community..." This is why for the National Ministry of Education "The strategic line of regional convergence of the National Development Plan 2022-2026 raises the need to promote territorial equity and overcome gaps in access to education from the preschool level to higher education" (Findeter, 2023).
- **Development of gamified Open Educational Resources (OER):** Promote the creation of and access to gamified OER specifically designed for the Colombian mathematics curriculum, which can be adapted and used by teachers. This could include platforms, educational games, design templates, and pedagogical guides.
- **Integration of gamification into the teacher training curriculum:** Incorporate gamification as a fundamental component in mathematics teacher training programs, ensuring that future educators are prepared to implement these methodologies from the start of their careers. Therefore, as Lozada and Betancur (2015, p. 99) state, "the constant need to update educational methods must be considered to improve the quality of education, which depends mainly on the content taught, the needs of society, and coverage." From this point of view, the integration of gamification is usually fundamental when it comes to strengthening teacher training.
- **Promotion of action-research in the classroom:** Encourage teachers themselves to conduct action-research in their classrooms to evaluate the effectiveness of gamification in their specific contexts, generating situated knowledge adapted to the realities of Bogotá.

The implementation of these recommendations requires a coordinated and sustained effort from all actors involved in Bogotá's educational system. By comprehensively addressing knowledge, attitudes, and contextual conditions, the foundations can be laid for a meaningful transformation in the teaching and learning of mathematics, preparing students for the challenges of the 21st century and fostering a positive attitude towards this fundamental discipline.

Discussion

The results obtained in this phase of the research confirm a widely recognized trend in the reviewed studies and also observed in the context of Bogotá: gamification continues to be valued by mathematics teachers as a pedagogical strategy with high potential to strengthen motivation, commitment, and meaningful understanding of content (Cáceres and Gómez, 2022). However, its real incorporation into classrooms faces structural and formative challenges similar to those identified in other Latin American contexts.

The evidence reveals that the knowledge mathematics teachers possess about gamification tends to be limited and, in many cases, superficial. As warned by Werbach and Hunter (2012), this reduced understanding often manifests in the adoption of basic mechanisms such as points, badges, or leaderboards without a clear pedagogical intentionality. This finding, also reported in Colombian research (Holguín et al., 2020; Palacios and Cimas, 2024), confirms that the absence of systematic training in gamification hinders the design of truly immersive learning experiences that are coherent with curricular objectives. Consequently, pedagogical innovation is frequently reduced to the superficial incorporation of playful elements, without achieving a significant transformation in mathematics teaching practices.

While teachers' attitudes towards gamification are predominantly positive, resistances persist that reflect tensions between innovation and pedagogical tradition. Some teachers express concern about the possibility that gamification might trivialize content or divert curricular focus, a perception also recorded by Cunza et al. (2025). These reservations are explained, to a large extent, by the lack of a comprehensive understanding of the methodology and the absence of institutional references guiding its application. National research, such as that by Prada et al. (2021) and Cárdenas and Chacón (2023), confirms that when gamification is implemented with pedagogical intentionality, structured planning, and curricular coherence, it generates significant changes in mathematics learning, even in populations with diverse educational needs. Thus, teacher attitude emerges not as an isolated factor, but as a key indicator of pedagogical appropriation and commitment to transforming traditional practices.

Among the external factors affecting the implementation of gamification, the availability of technological resources and institutional support emerge as the most determining. The findings of this review coincide with national reports that show the persistence of a significant digital divide in the country, where only 51.9% of households have stable internet access (Departamento Administrativo Nacional de Estadística, 2020). This inequality limits the possibility of integrating gamified tools in classrooms, especially in Bogotá's public schools. Although recent studies recognize advances in infrastructure and connectivity, structural and formative deficiencies persist that restrict the scope of these strategies (Moya and Díaz, 2024). In this way, teacher digital literacy and sustained investment in educational infrastructure are consolidated as indispensable conditions for an effective and equitable implementation of gamification in mathematics teaching.

Finally, the recent results of the Saber 11 tests (Icfes, 2025) offer an important context for interpreting the findings of this research. The fact that the majority of students are concentrated at a basic performance level (Level 3) and only a small percentage reach advanced levels highlights the need to rethink the pedagogical strategies used in mathematics teaching. In this scenario, gamification emerges as a viable alternative to strengthen critical thinking, problem-solving, and the application of knowledge in real contexts, competencies characteristic of the higher performance levels. Consequently, gamification, implemented in a planned manner and coherent with curricular objectives, can contribute to transforming traditional teaching, centered on mechanical repetition, into an active, motivating, and meaningful learning experience.

The main finding of this study is that teacher training constitutes the most determining axis for closing the gap between the theoretical potential of gamification and its real application in the classroom. It

is not enough to introduce digital tools or resources; it is essential for teachers to develop pedagogical competencies to design gamified experiences coherent with curricular objectives and the characteristics of their students. This requires a deep understanding of the psychological foundations of motivation, the appropriate selection of game mechanics, the didactic planning of challenges, and the ability to evaluate both learning processes and results. Gamification, understood from this pedagogical perspective, can become a strategy for educational transformation that enhances critical thinking, problem-solving, and student autonomy in mathematics.

Secondly, it is possible that teachers' positive attitudes towards gamification serve as a valuable starting point, though insufficient on their own. For these attitudes to translate into sustainable practices, an institutional environment that favors innovation is required. This implies guaranteeing access to updated technological resources, having time for the planning and design of gamified experiences, and promoting educational leadership that recognizes and stimulates transformative pedagogical initiatives. Without this structural and cultural scaffolding, teachers' motivation risks being diluted in the face of practical barriers, perpetuating the distance between innovative discourse and educational action.

Thirdly, the educational context of Bogotá and by extension in Colombia poses structural challenges that condition the implementation of gamification, among them the persistent digital divide and the inequality of resources between public and private institutions. For gamification to transcend isolated experiences and consolidate as a sustainable strategy, public policies are required that guarantee equitable technological infrastructure, accompanied by continuous teacher training processes. Furthermore, it is essential to promote the development of open and gamified educational resources, designed in coherence with the national curriculum and accessible to the entire educational community. Only through this articulation between pedagogical innovation, technological equity, and educational policy will it be possible to effectively transform mathematics teaching in the country.

Finally, gamification should not be conceived as a total response to educational challenges, but as a complementary strategy within an ecosystem of active methodologies oriented towards meaningful learning. Its true value lies in its capacity to transform the way students perceive mathematics, reducing anxiety and revealing the applicability of this discipline in solving real problems. For the students of Bogotá, a pedagogically well-founded gamification strategy represents a tangible opportunity to develop critical thinking, creativity, and conceptual understanding, competencies indispensable for facing the cognitive and social challenges of the 21st century.

Conclusions

This systematic review on the knowledge and attitudes of mathematics teachers in Bogotá towards gamification reveals a central paradox: there is broad recognition of its potential to motivate students and dynamize learning, but its practical and effective application is still incipient and faces significant barriers.

The main conclusion is that teacher training is the most determining factor for overcoming the gap between the theoretical potential of gamification and its reality in the classroom. Teachers require training that transcends the introduction to tools and focuses on the pedagogical design of gamified ex-

periences. This implies understanding the psychological foundations of motivation, adjusting game mechanics with curricular objectives in mathematics, and learning to evaluate both the process and the results of learning in gamified environments.

Secondly, it is concluded that teachers' positive attitudes are a valuable starting point, but insufficient. These must be supported by favorable institutional conditions, which include access to adequate technological resources, time allocated for planning and designing these strategies, and educational leadership that values and promotes pedagogical innovation. Without this scaffolding, teacher motivation can decline in the face of practical difficulties.

Thirdly, the context of Bogotá, and by extension of Colombia, imposes structural challenges such as the digital divide and resource inequality between institutions. A successful implementation of gamification on a large scale requires public policies that ensure equitable technological infrastructure and the development of open gamified educational resources, adapted to the national curriculum and accessible to all teachers.

Finally, gamification should not be seen as a panacea, but as a powerful complementary strategy within a range of active methodologies. Its true value lies in its capacity to transform the perception of mathematics, reducing anxiety and demonstrating its relevance in problem-solving contexts. For the students of Bogotá, mostly stuck in procedural mathematical performance, well-oriented gamification represents a tangible opportunity to develop critical thinking and a deeper conceptual understanding, skills indispensable for the challenges of the 21st century.

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