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Teachers' Role in Implementing Roblox-Based Gamification to Enhance Fourth-Grade Students' Motivation in Learning Equivalent Fractions

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Abstract

Mathematics learning in elementary schools often faces challenges related to low student motivation and mathematics anxiety. Although gamification has been recognized as an effective strategy for increasing student engagement, most studies have focused on 2D quiz-based applications such as Kahoot and Quizizz, while the use of immersive virtual 3D platforms such as Roblox remains limited. This study explored teachers' roles in enhancing fourth-grade students' motivation to learn equivalent fractions through Roblox-based gamification. A qualitative case study was conducted using semi-structured interviews, classroom observations, and documentation involving a fourth-grade teacher, a principal, and 28 fourth-grade students (with six key informants) at SDN Kapuk 02 Pagi, West Jakarta. Learning was delivered using the customized 3D map "Mount Matematika Pecahan Senilai". The findings revealed that the teacher effectively functioned as an adventure-mission designer and learning facilitator, restructuring abstract fraction problems into progressive digital quests. Consequently, students voluntarily repeated fraction challenges after unsuccessful attempts, collaborated to solve obstacle-based tasks, and became more confident in explaining equivalent fraction concepts during discussions. Teachers also reported that previously passive students participated more actively and showed greater persistence in completing learning tasks. These findings imply that integrating teacher-guided immersive virtual Roblox-based gamification provides an innovative, learner-centered paradigm for elementary mathematics instruction.

Keywords: Gamification, Learning Motivation, Mathematics, Roblox, Teachers' Role

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Abstrak

Pembelajaran matematika di sekolah dasar sering kali menghadapi tantangan terkait rendahnya motivasi siswa dan kecemasan terhadap matematika. Meskipun gamifikasi telah diakui sebagai strategi yang efektif untuk meningkatkan keterlibatan siswa, sebagian besar penelitian berfokus pada aplikasi berbasis kuis 2D seperti Kahoot dan Quizizz, sementara penggunaan platform 3D virtual imersif seperti Roblox masih terbatas. Penelitian ini mengeksplorasi peran guru dalam meningkatkan motivasi siswa kelas empat untuk mempelajari pecahan setara melalui gamifikasi berbasis Roblox. Studi kasus kualitatif dilakukan dengan menggunakan wawancara semi terstruktur, observasi kelas, dan dokumentasi yang melibatkan seorang guru, kepala sekolah, dan 28 siswa kelas IV (dengan 6 siswa sebagai informan utama) di SDN Kapuk 02 Pagi, Jakarta Barat. Pembelajaran yang dikaji menggunakan peta kustom "Mount Matematika Pecahan Senilai". Temuan menunjukkan bahwa guru berperan strategis sebagai perancang misi dan fasilitator yang mengonversi soal pecahan abstrak menjadi rintangan digital terstruktur. Hasilnya siswa secara sukarela mengulangi tantangan pecahan setelah beberapa kali gagal, berkolaborasi untuk memecahkan tugas berbasis rintangan, dan menjadi lebih percaya diri dalam menjelaskan konsep pecahan setara selama diskusi. Guru juga melaporkan bahwa siswa yang sebelumnya pasif menjadi lebih aktif berpartisipasi dan menunjukkan ketekunan yang lebih besar dalam menyelesaikan tugas pembelajaran. Temuan ini menegaskan bahwa gamifikasi imersif berbasis Roblox terbimbing oleh guru menawarkan pendekatan inovatif yang bermakna dan berpusat pada siswa dalam pembelajaran matematika sekolah dasar.

Kata Kunci: Gamifikasi, Motivasi Belajar, Pembelajaran Matematika, Roblox, Peran Guru

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INTRODUCTION

Elementary education is a foundational level that plays a strategic role in shaping students' cognitive, affective, and psychomotor competencies. At this stage, the instructional process aims not merely at academic achievement, but also at cultivating positive learning dispositions, self-confidence, critical thinking, and sustainable learning motivation. Learning motivation serves as a pivotal determinant of educational success, as highly motivated students exhibit greater active engagement, enthusiasm, and academic resilience when encountering conceptual difficulties (Mohammed et al., 2024). Consequently, enhancing instructional quality in primary schools represents a strategic imperative to foster human resources capable of navigating rapid advancements in science and technology.

However, mathematics remains a formidable pedagogical challenge in elementary schools. The subject is frequently perceived as excessively abstract, demanding rigorous logical and systematic reasoning. This cognitive barrier often triggers low self-efficacy and pervasive mathematics anxiety, manifesting in passive classroom participation, reluctance to inquire or respond, and poor task persistence. This suboptimal engagement stems largely from conventional, teacher-centered instructional practices dominated by one-way procedural transmission and rote memorization. Such approaches strip mathematical ideas of real-world context, leaving students disengaged and undermining their intrinsic motivation, causing them to participate merely to satisfy external academic demands rather than genuine intellectual curiosity (Ryan & Deci, 2020).

Conversely, contemporary elementary school students represent digital natives whose cognitive and social habits are deeply shaped by interactive technologies, including computers, mobile devices, and online gaming environments. These learners respond most effectively to visual, experiential, challenge-driven activities that deliver immediate feedback (Marquardt et al., 2025). This generational shift necessitates innovative pedagogical frameworks, most notably gamification—defined as the integration of game mechanics such as points, levels, challenges, badges, and leaderboards into non-game learning contexts (Septiandi et al., 2026). When properly structured, gamification enhances behavioral engagement, creates low-anxiety learning atmospheres, and stimulates both intrinsic and extrinsic motivation (Muhajir et al., 2025). Within this paradigm, learners transition from passive recipients into active problem-solvers navigating meaningful mathematical missions.

The pedagogical efficacy of gamification is significantly magnified when coupled with immersive virtual platforms such as Roblox. As a three-dimensional collaborative virtual environment, Roblox allows learners to construct, navigate, and interact within dynamic digital worlds. In mathematics education, particularly for equivalent fractions, Roblox addresses critical limitations inherent in traditional concrete manipulatives, such as paper cutouts or fraction bars, which, while tangible, remain static, functionally non-interactive, and constrained by physical wear or rigid classroom time limits. Through dynamic 3D simulations, Roblox enables multi-representational modeling where proportional relationships, scale variations, and fraction equivalences can be dynamically transformed, tested, and visualized in real time (Sari et al., 2026). Furthermore, the platform's core affordances such as exploratory quests, collaborative navigation, and scaffolded feedback loops, satisfy students' basic psychological needs for autonomy, competence, and relatedness, which Self-Determination Theory identifies as foundational to sustained intrinsic motivation (Ryan & Deci, 2020). Although prior studies confirm that gamification generally enhances engagement and learning outcomes, direct empirical research examining Roblox in primary mathematics, specifically for equivalent fractions in fourth grade, remains scarce. Existing literature has predominantly evaluated

generalized game applications or quiz-based mechanics without examining the nuanced pedagogical processes, immersive student learning experiences, or practical constraints within primary classrooms (Berdousis, 2025).

Addressing low mathematics motivation among fourth-grade students thus demands an instructional paradigm shift that aligns technological affordances with modern learners' cognitive profiles. Roblox-based gamification presents substantial potential to transform abstract mathematics instruction into an interactive, experiential, and collaborative journey (Ratinho et al., 2026). Nevertheless, realizing this potential fundamentally hinges on the teacher's deliberate pedagogical agency. An immersive platform cannot generate learning autonomously; its instructional value depends on how teachers curate gamified storylines, design targeted mathematical obstacles, provide adaptive cognitive scaffolding, and facilitate post-game reflective debriefing. Therefore, this study investigates the teacher's role in orchestrating Roblox-based gamification in fourth-grade mathematics, specifically evaluating its operational implementation, instructional affordances, practical barriers, and measurable contribution to students' learning motivation (Prasetyo & Meiliasari, 2025). The findings are expected to advance theoretical frameworks surrounding immersive gamification while providing actionable pedagogical guidance for educators seeking to leverage metaverse-based platforms in digital-era primary mathematics education.

METHODS

This study employed a qualitative approach with a case study design to gain an in-depth understanding of the implementation of Roblox-based gamification in enhancing fourth-grade elementary school students' motivation to learn mathematics. A qualitative design was selected because the inquiry focused on understanding a real-world educational phenomenon as it naturally unfolded within a school setting, thereby enabling the researcher to capture nuanced data regarding instructional dynamics, teacher–student interactions, and experiential learning processes throughout the pedagogical intervention (Septiandi et al., 2026). The case study approach was specifically chosen to examine a bounded contemporary case: the pedagogical design, execution, and motivational impact of gamified mathematics instruction using the Roblox platform in a fourth-grade classroom. This approach allowed for a holistic exploration of how the classroom teacher conceptualized, implemented, and adapted gamified instructional strategies, as well as how learners responded affectively and behaviorally to the gamified learning environment (Algburi et al., 2026).

The research was conducted at SDN Kapuk 02 Pagi, West Jakarta, during the 2025/2026 academic year. The research participants consisted of one fourth-grade classroom teacher as the primary informant, the school principal as an institutional key informant, and fourth-grade students who actively participated in mathematics lessons on equivalent fractions delivered through the Roblox platform. The classroom teacher was purposefully selected due to their central role in orchestrating instructional design, developing game-integrated tasks, and moderating classroom dynamics. Concurrently, the participating students served as essential informants to evaluate shifts in learning motivation, task persistence, and direct experiential engagement during gamified sessions (Yuliani & Kaltsum, 2026). The primary object of inquiry centered on the teacher's operationalization of gamification mechanisms via the Roblox platform to foster elementary students' motivation toward learning equivalent fractions.

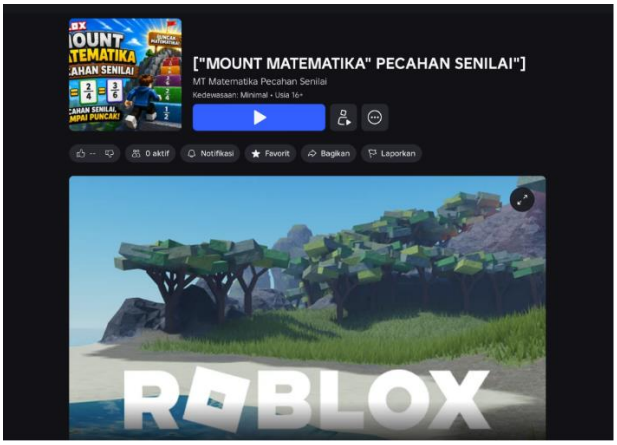

Figure 1. Screenshot of the Map Name in Roblox (Mount Matematika Pecahan Senilai)

Data were collected through three convergent qualitative techniques: classroom observation, semi-structured interviews, and documentary analysis. Non-participant and participant classroom observations were conducted across all instructional phases (introductory orientation, core gameplay missions, and reflective debriefing) to systematically document instructional interactions, students' behavioral and emotional engagement, and peer-assisted problem solving during Roblox-integrated fraction tasks (Pan et al., 2026). Semi-structured interviews were conducted with the classroom teacher, the principal, and key student informants to uncover perspectives on instructional planning, pedagogical benefits, technological hurdles, perceived self-efficacy, and affective shifts in mathematical curiosity (Brinkmann & Kvale, 2018). In addition, comprehensive documentation was gathered, including instructional lesson plans, curricular materials, photographic records of classroom sessions, student activity sheets, and digital gameplay progress screenshots, serving as corroborative evidence to validate observation and interview findings (Bowen, 2009).

The gathered empirical data were analyzed using the interactive qualitative analysis framework articulated by Miles, Huberman, and Saldaña, encompassing data condensation, data display, and conclusion drawing/verification (Steinrücke et al., 2023). Data condensation was performed by extracting, focusing, and systematically coding transcriptions and field notes into categorical themes aligned with the research objectives, specifically gamified instructional design, motivational behaviors, conceptual fraction mastery, and classroom management constraints. The categorized data were displayed through structured narrative syntheses, thematic matrices, and representative verbatim excerpts to identify empirical patterns and relational dynamics across data streams. Subsequently, emergent conclusions were drawn and iteratively verified through continuous comparative interpretation to ensure congruence with the empirical realities observed in the classroom.

To establish methodological rigor and trustworthiness, the study integrated four comprehensive data validation techniques: source triangulation, methodological triangulation, member checking, and audit trail maintenance (Huang et al., 2023). Source triangulation involved systematically comparing narratives obtained from the teacher, school principal, and students. Methodological triangulation was executed by cross-verifying observational records against interview responses and physical instructional artifacts. Member checking was administered by returning reconstructed transcripts and preliminary interpretive summaries to the informants to ensure interpretive accuracy, while an audit trail was maintained through detailed chronological

records of all raw field notes, coding schemes, and analytic memos (Mannila et al., 2023). Through this rigorous methodological design, the investigation yielded a credible, dependable, and comprehensive account of the teacher's role in leveraging Roblox-based gamification to enhance elementary students' motivation in learning equivalent fractions.

RESULTS AND DISCUSSION

The qualitative findings of this study delineate how the teacher designed and enacted gamified instruction using the custom Roblox map "Mount Matematika Pecahan Senilai" and how this pedagogical intervention reshaped fourth-grade students' learning motivation and classroom dynamics. Through data condensation and triangulation across classroom observations, in-depth interviews, and instructional artifacts, the empirical results are organized into four central themes: (1) instructional transformation and teacher mission design; (2) shifts in students' intrinsic motivation and task persistence; (3) dynamic visual representation of equivalent fractions; and (4) the normalization of academic trial-and-error within collaborative spaces.

Transforming Instruction: The Teacher as Adventure-Mission Architect

Classroom observations revealed that the teacher deliberately shifted the instructional paradigm away from traditional whiteboard drill-and-practice toward an immersive, mission-based quest. The lesson commenced with a concrete orientation linking real-world proportional sharing (a pizza illustration) to the challenges embedded within the virtual mountain environment. Mathematical word problems and fractions worksheets were converted into checkpoint-based adventure quests. As the fourth-grade teacher explained during the interview:

> *"I usually transform word problems into adventures that are closely connected to children's world. For example, students become explorers who must collect pieces of a hidden treasure. To unlock the treasure chest, they have to solve equivalent fraction problems. In this way, students focus more on completing the challenge than on the fact that they are solving difficult mathematics problems."*

Figure 2. Students Collaborating in Small Groups to Navigate the Equivalent Fraction Mountain Challenge in Roblox

Observational field notes confirmed that the classroom was arranged into collaborative pods sharing laptop devices. Students took turns manipulating digital avatars to traverse virtual terrain, where advancing through gates or climbing sections required identifying mathematically equivalent fractions (e.g., matching 1/2 to 2/4 or 3/6). When individual students encountered

bottlenecks regarding numerator–denominator proportional growth, the teacher stepped in not to provide answers, but to offer immediate scaffolding using in-game visual prompts until the conceptual link was mastered.

Shifts in Student Learning Motivation and Task Engagement

The implementation of the gamified platform induced a visible behavioral and emotional shift among students, particularly those previously characterized by instructional disengagement. Observational data indicated heightened attention spans, self-initiated participation, and vocal excitement during problem-solving tasks. The classroom teacher highlighted this marked transformation:

> *"I observed a remarkable increase in students' enthusiasm. When Roblox was used, they became more active in asking questions, participating in discussions, and attempting to complete the challenges. Even students who were usually passive became much more involved in the learning process. They appeared more confident and were no longer afraid of making mistakes because the learning atmosphere felt like playing a game."*

Student interviews corroborated these observational accounts, revealing that the novelty and recreational familiarity of Roblox bridged their interest into academic work. One student noted:

> *"I was really surprised. At first, I thought the teacher was joking. I became so excited and couldn't wait to try it."*

Another student contrasted their prior textbook experiences with the gamified session:

> *"Working in the workbook is boring, but with Roblox it feels like we're going on an adventure."*

The combination of clear goals, level progression, and incremental rewards sustained students' focus throughout the instructional block, encouraging voluntary academic effort rather than compliance driven merely by grading requirements.

Dynamic Visualization and Conceptual Comprehension

A critical obstacle identified during baseline observations was students' persistent confusion regarding how fractions with differing numerical digits could hold identical quantities. The teacher emphasized that conventional 2D illustrations frequently failed to convey relational equivalence dynamically:

> *"The main challenge is that students find it difficult to imagine that two fractions with different numbers can actually represent the same value."*

Within the Roblox environment, fractional quantities were represented as scalable physical structures and environmental pathways. Interacting directly with these digital models provided learners with immediate visual verification of numerical relationships. The teacher observed:

> *"In my opinion, the visualizations in Roblox help students understand the concept much better because they can directly observe the relationships among equivalent fractions."*

During the lesson synthesis, students demonstrated concrete conceptual gains during verbal questioning, spontaneously articulating why 1/2 is structurally identical to 2/4 and 3/6 by referencing landmarks and blocks encountered on the virtual mountain.

Establishing a Safe Failure Space and Peer Collaboration

Rather than evoking anxiety or academic resignation, in-game errors functioned as constructive feedback mechanisms. When students chose an incorrect fraction path, the virtual avatar was simply returned to the preceding checkpoint, allowing for immediate reiteration. Interviews revealed that this mechanic neutralized math-related fear:

> *"I wasn't afraid at all. Instead, I became even more curious. I just kept trying different answers until I finally got through."*

This low-stakes environment directly fostered spontaneous peer-to-peer scaffolding. Observational logs documented higher-performing peers guiding group members through difficult paths rather than simply providing answers. A student illustrated this supportive behavior:

> *"I went over to my friend's character, showed them the correct path, and explained it. It was really fun—it felt like playing together at home while learning at school."*

Institutional Support and Practical Implementation Bottlenecks

Alongside these pedagogical affordances, the findings identified clear pragmatic constraints. The classroom teacher noted that time management presented a recurring challenge, as students occasionally prioritized avatar navigation and virtual exploration over timely task completion. Additionally, disparities in hardware availability necessitated group device-sharing models. From an administrative perspective, the school principal affirmed support for immersive learning innovations while accentuating infrastructural prerequisites:

> *"Continuous training and mentoring are still needed so that teachers feel more confident and are better able to integrate technology into learning in ways that effectively support instructional objectives."*

The principal reiterated that institutional integration of virtual platforms requires robust school internet infrastructure, deliberate lesson scaffolding by educators, and continuous professional development to safeguard instructional intentionality against digital distraction.

Discussion

The empirical findings demonstrate that integrating Roblox-based gamification into elementary mathematics instruction transforms the learning process from conventional, passive drill-and-practice into an active, exploratory, and student-centered experience. Prior to this intervention, mathematics learning was dominated by teacher-centered instruction and rote problem solving, which induced disengagement and anxiety among students. By contextualizing equivalent fractions into interactive quests and obstacle-based challenges, the teacher fostered genuine learning motivation, task persistence, and active participation. This aligns with Bakker et al. (2015), who demonstrated that game-based learning environments in primary mathematics

shift mechanical problem solving into engaging exploratory activities that foster multiplicative and proportional reasoning. These findings support the empirical evidence synthesized by Bai et al. (2020), who demonstrated that digital-based gamification substantially enhances student engagement and learning drives by framing instructional activities into interactive and contextual tasks. These findings corroborate the empirical evidence presented by Mohammed et al. (2024), who observed that well-structured gamification enhances primary students' enthusiasm and learning resilience when tackling challenging school subjects.

The heightened motivation observed in this study is directly rooted in Self-Determination Theory (SDT) as formulated by Ryan and Deci (2020). Within the Roblox map, students' basic psychological needs such as autonomy, competence, and relatedness, were systematically satisfied. Autonomy was nurtured because students had the agency to choose navigation paths and problem-solving strategies rather than passively executing rigid procedural steps. Competence was reinforced through immediate in-game feedback at each checkpoint, confirming mathematical accuracy in real time. Concurrently, relatedness developed through spontaneous peer collaboration, where students guided each other to solve fractional barriers. This alignment reinforces Berdousis (2025), who argued from an SDT perspective that gamification in elementary classrooms successfully activates internal motivational drives when instructional tasks support learner agency and peer interaction.

Furthermore, the design of the Roblox environment resonates with the cognitive profile of contemporary elementary learners. As Marquardt et al. (2025) highlighted, modern digital-native students gravitate toward purposeful learning activities that provide visual richness, interactive mechanics, and immediate feedback. Abstract concepts such as equivalent fractions pose persistent cognitive hurdles when taught solely through static 2D worksheets. Within the 3D space of "Mount Matematika Pecahan Senilai", proportional relationships (such as ½ = 2/4 = 3/6) were visualized dynamically as traversable architectural models. This dynamic visualization enabled students to construct concrete mental representations before translating them into formal mathematical notations, aligning with Sari et al. (2026), who demonstrated that gamified simulations bridge abstract elementary mathematics concepts into comprehensible representations. This also reinforces the findings of Moyer-Packenham and Westenskow (2013), who demonstrated that dynamic virtual manipulatives effectively reduce cognitive load and enhance mathematical concept formation compared to static materials.

A key novelty of this study lies in how the 3D gamified platform established a safe failure space that fundamentally dismantled students' fear of making mistakes. In conventional mathematics settings, instructional failure often triggers embarrassment and anxiety. In contrast, the game mechanics implemented via Roblox treated incorrect answers as routine diagnostic opportunities to retry without punitive grading consequences. This dynamic directly reflects the conclusions of Pan et al. (2026), who reported that gamified tasks featuring levels and structured progression foster high behavioral engagement by normalizing failure as an iterative stepping stone toward mastery. Rather than withdrawing from the task, students demonstrated sustained persistence until they successfully advanced to the next checkpoint.

The findings also provide critical practical insights into the indispensable role of the teacher. In line with Yuliani and Kaltsum (2026), gamified and concrete learning cannot operate autonomously; its success relies on the teacher's deliberate orchestration as an instructional architect and facilitator. This echoes Maya-Jariego et al. (2023), who emphasized that the successful digitization of classroom learning depends heavily on proactive teacher agency and collaborative networks within the school ecosystem. In this study, the teacher did not merely

assign gameplay, but converted standard mathematical word problems into meaningful quests, provided real-time scaffolding during student impasses, and facilitated reflective debriefing sessions. This structured pedagogical facilitation ensured that gameplay directly served curricular objectives.

Finally, while the broader literature confirms the general benefits of gamification on student engagement across educational levels (Algburi et al., 2026; Prasetyo & Meiliasari, 2025; Ratinho et al., 2026; Septiandi et al., 2026), this study offers distinct empirical value by documenting direct implementation in an Indonesian elementary school setting using a metaverse-based platform. However, as noted in the findings, effective implementation introduces practical challenges, including classroom time management and hardware limitations. Addressing these barriers requires strategic instructional planning and continuous teacher professional development, ensuring that immersive gamification functions as an effective, sustainable pedagogy for digital-era primary mathematics education.

CONCLUSION

This study concludes that the implementation of Roblox-based gamification, specifically through the custom map "Mount Matematika Pecahan Senilai", effectively transforms elementary mathematics instruction from a conventional, passive routine into an interactive, student-centered learning experience. By integrating obstacle-based challenges, dynamic 3D visualizations, and collaborative quests, the platform systematically enhances fourth-grade students' learning motivation. This motivational shift is empirically evidenced by heightened classroom engagement, sustained persistence following task failure, spontaneous peer-assisted learning, and increased confidence in articulating the concept of equivalent fractions. Crucially, the platform creates a safe failure space that deconstructs mathematics anxiety, allowing learners to treat academic errors as productive opportunities for iteration rather than indicators of inability.

The findings also underscore that the pedagogical success of immersive gamification relies heavily on the teacher's intentional agency. The virtual environment does not operate effectively in isolation; rather, its instructional value depends on the teacher's deliberate alignment of game missions with curriculum standards, timely cognitive scaffolding during student impasses, and structured post-game debriefings. Practically, schools and educators must address implementation trade-offs, particularly regarding classroom time management and digital hardware availability. For sustainable adoption, educational institutions should bolster digital infrastructure and provide targeted professional development to elevate teachers' digital pedagogical readiness which aligns with the findings of Georgiou et al. (2023) regarding the critical determinants of teachers' technology acceptance and integration in primary schools. Future research should expand beyond a single classroom setting to investigate the long-term cognitive impact of Roblox-based gamification across diverse mathematical topics and varied grade levels using mixed-methods or experimental designs.

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