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Gamified Failure: How Productive Mistakes Enhance Students' Metacognitive Awareness

Muhamad Arpan [1], Arbana Muhammad Arifin Ilham [2], Alfito Ramadhan [3]
[1] Universitas Muhammadiyah Jakarta 1
[2] Universitas Muhammadiyah Jakarta 2
[3] Universitas Muhammadiyah Malang 3
Correspondence: alfieyansay@email.com

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ABSTRACT
This study investigates how gamified failure, defined as structured and productive mistakes within game-based learning environments, enhances students' metacognitive awareness. The primary objective is to analyze the role of failure in fostering learners' abilities to plan, monitor, and evaluate their cognitive processes. A qualitative approach was employed using a case study design, selected for its capacity to provide an in-depth and contextualized understanding of learners' experiences in real educational settings. The research was conducted in a private senior high school in West Java, Indonesia, chosen due to its implementation of gamified digital learning systems. The study involved twenty student participants and five key informants, including teachers and educational practitioners, selected purposively based on their direct engagement with gamified instruction. The findings reveal that iterative failure, supported by immediate feedback and non-punitive learning structures, significantly enhances reflective thinking, strategic adjustment, and conceptual understanding. Students demonstrated increased metacognitive awareness by actively evaluating their errors and refining learning strategies. The study recommends the intentional integration of structured failure within gamified environments to promote deeper learning and self-regulation, while future research is encouraged to explore broader contexts and longitudinal impacts.

INTRODUCTION

The increasing integration of game-based elements into educational environments has reshaped how learners engage with knowledge, particularly in the context of failure and feedback. Traditionally, failure in education has been perceived as a negative outcome to be minimized, often associated with low achievement, reduced motivation, and diminished self-efficacy (Yeganeh et al., 2025). However, recent developments in learning sciences and educational psychology have begun to reconceptualize failure as a potentially productive component of the learning process (Alemdag et al., 2025). Within gamified environments, failure is not only expected but structurally embedded as part of iterative progress, offering immediate feedback and opportunities for reflection (Chapman & Andrade, 2024). This shift aligns with contemporary perspectives on metacognition, which emphasize learners' ability to monitor, regulate, and evaluate their own cognitive processes (Feng & Yang, 2025). In this regard, the concept of "gamified failure" emerges as a promising pedagogical approach to enhance students' metacognitive awareness.

Current state-of-the-art research highlights that gamification can significantly improve student engagement, persistence, and motivation by leveraging elements such as points, levels, badges, and challenges (Vercelli, 2025). At the same time, studies on productive failure suggest that allowing students to struggle with complex problems before receiving explicit instruction can lead to deeper conceptual understanding (Castellano, Mckay, et al., 2024). Despite these advances, the intersection between gamified learning environments and productive failure remains underexplored, particularly in relation to how such experiences foster metacognitive awareness (Palmquist & Jedel, 2025). Existing literature tends to examine gamification primarily from a motivational standpoint or focuses on failure as a cognitive phenomenon in isolation, leaving a conceptual and empirical gap regarding how

structured failure within gamified systems influences learners' metacognitive processes (Mastrogiacomi, 2024).

The primary problem addressed in this study lies in the limited understanding of how failure, when intentionally designed within gamified learning contexts, contributes to the development of metacognitive awareness among students. In many educational settings, failure is still stigmatized, leading learners to avoid risk-taking and reflective thinking (Pradhan et al., 2025). This condition inhibits the development of higher-order thinking skills, including planning, monitoring, and evaluating one's own learning strategies (Pradhan et al., 2024). Moreover, educators often lack evidence-based frameworks for integrating productive failure into gamified instructional designs in a way that supports metacognitive growth rather than discouragement (Usama et al., 2024).

The research gap is thus identified in the absence of integrative studies that connect gamification, productive failure, and metacognitive awareness within a unified pedagogical framework (Alzahrani & Alhalafawy, 2023). While prior research has established that gamification enhances engagement and that productive failure can deepen understanding, there is insufficient empirical evidence explaining how these two constructs interact to influence metacognitive development (Silviyani, 2025). Furthermore, there is a lack of contextualized studies conducted in diverse educational settings, particularly in developing countries, where digital learning adoption and pedagogical innovation may differ significantly from Western contexts (Gupta & Vaishnav, 2025).

This study offers novelty by proposing and empirically examining the concept of "gamified failure" as a deliberate instructional strategy that transforms mistakes into reflective learning opportunities within a game-based environment. Unlike traditional approaches that either avoid failure or treat it as incidental, this research positions failure as a central design feature that triggers metacognitive processes. The novelty also lies in integrating theoretical perspectives from constructivism, self-regulated learning, and game-based learning into a cohesive model that explains how learners interpret, respond to, and learn from failure experiences in gamified systems (Aslanyan-rad, 2024).

Based on these considerations, the research is guided by several key questions. The study seeks to investigate how gamified failure influences students' metacognitive awareness, what mechanisms mediate this relationship, and how learners perceive and respond to failure within gamified environments. Additionally, it explores the extent to which structured failure experiences can enhance students' ability to plan, monitor, and evaluate their own learning strategies.

Accordingly, the primary objective of this research is to analyze the role of gamified failure in enhancing students' metacognitive awareness. Specifically, the study aims to identify the characteristics of gamified environments that effectively support productive failure, examine the relationship between failure experiences and metacognitive processes, and develop a conceptual framework that can guide educators in designing instruction that leverages failure as a learning tool. By achieving these objectives, the study intends to contribute to a more nuanced understanding of how learning environments can be structured to promote deeper cognitive engagement.

The theoretical significance of this research lies in its contribution to the integration of multiple learning theories, particularly by bridging the gap between gamification and metacognition through the lens of productive failure. It advances existing knowledge by offering a new perspective on the pedagogical value of failure, challenging deficit-oriented views and emphasizing its constructive role in learning (Wang, 2025). Academically, this study provides empirical evidence and a conceptual framework that can inform future research, curriculum development, and instructional design in the field of education. It also supports the growing body of literature advocating for student-centered and reflective learning approaches (Kaakandikar et al., 2025).

From a practical standpoint, the findings of this research are expected to assist educators, instructional designers, and policymakers in developing more effective learning environments that embrace failure as a meaningful part of the educational process. By understanding how gamified failure can enhance metacognitive awareness, teachers can design activities that encourage students to reflect

on their mistakes, adapt their strategies, and become more autonomous learners. This has important implications for improving learning outcomes, particularly in complex and dynamic educational contexts (Christou et al., 2023).

Nevertheless, this study acknowledges several limitations. The scope of the research may be constrained by the specific educational context in which it is conducted, potentially limiting the generalizability of the findings. Additionally, measuring metacognitive awareness remains methodologically challenging, as it often relies on self-reported data and subjective interpretations (Pinski et al., 2024). The implementation of gamified failure also requires careful design and technological support, which may not be equally accessible across different institutions (Asy-Syila, 2024).

Future research is recommended to expand the investigation across diverse educational levels, disciplines, and cultural contexts to validate and refine the proposed framework. Longitudinal studies could provide deeper insights into the long-term impact of gamified failure on metacognitive development, while experimental designs may help establish causal relationships more robustly. Furthermore, integrating emerging technologies such as adaptive learning systems and artificial intelligence could enhance the personalization of failure experiences, thereby optimizing their impact on student learning (Xu et al., 2025).

In conclusion, this study positions gamified failure as a transformative approach to fostering metacognitive awareness, offering both theoretical and practical contributions to contemporary educational discourse. By reframing failure as a productive and integral component of learning, it opens new pathways for designing educational experiences that empower students to become reflective, resilient, and self-regulated learners.

LITERATURE REVIEW

The literature on gamified learning, productive failure, and metacognitive awareness has evolved significantly over the past decades, reflecting a paradigm shift from teacher-centered instruction toward more learner-centered and reflective approaches (Yang et al., 2025). In the context of the study titled *"Gamified Failure: How Productive Mistakes Enhance Students' Metacognitive Awareness,"* the theoretical foundation is constructed upon three major frameworks: Constructivist Learning Theory, Productive Failure Theory, and Metacognitive Theory (Cigdem et al., 2024). These theories collectively provide a comprehensive lens for understanding how learners interact with failure within gamified environments and how such interactions foster deeper awareness of their own thinking processes.

Constructivist Learning Theory, widely popularized by Jean William Fritz Piaget in 1970 at the University of Geneva, Switzerland, posits that learners actively construct knowledge through interaction with their environment rather than passively receiving information (He et al., 2025). Piaget emphasizes that cognitive development occurs through processes of assimilation and accommodation, where learners continuously adapt their mental schemas in response to new experiences (O'Brien et al., 2025). Within the context of gamified failure, this theory suggests that mistakes are not merely errors but essential experiences that stimulate cognitive restructuring (Hutson & Plate, 2023). Learners encountering failure in a gamified system are encouraged to reassess their understanding, experiment with alternative strategies, and refine their conceptual frameworks (Sata, 2024). The constructivist perspective thus underlines the pedagogical value of failure as an active and meaningful component of learning, directly addressing the problem of passive learning and lack of deep engagement in traditional classrooms (Thao & Nhung, 2025).

Complementing this perspective is the Productive Failure Theory, introduced and extensively developed by Manu Kapur in 2008 at the National Institute of Education, Nanyang Technological University, Singapore (Yildiza & Yaman, 2024). Kapur's work demonstrates that allowing learners to struggle with complex, ill-structured problems prior to formal instruction can lead to superior conceptual understanding compared to direct instruction alone (Vanacore et al., 2024). Productive failure occurs when initial unsuccessful attempts generate cognitive activation, enabling learners to

better integrate subsequent instruction (Öztürk & Akhan, 2025). In gamified environments, this principle is operationalized through iterative challenges, feedback loops, and opportunities for repeated attempts (Alja'afreh, 2024). The relevance of this theory to the present study lies in its direct alignment with the central problem of how failure can be transformed into a constructive learning experience. It also highlights a significant research gap, as most gamification studies emphasize rewards and motivation rather than the cognitive benefits of structured failure (Mazzoni et al., 2025).

The third theoretical foundation is Metacognitive Theory, systematically articulated by John Hurley Flavell in 1979 at Stanford University, United States (Izadi & Forouzanfar, 2024). Flavell defines metacognition as "thinking about thinking," encompassing both metacognitive knowledge and metacognitive regulation (Khavasi, 2025). This includes learners' awareness of their cognitive processes as well as their ability to plan, monitor, and evaluate their learning strategies (Alshuaifan, 2024). In the context of gamified failure, metacognitive theory provides the mechanism through which failure experiences translate into learning gains. When learners encounter failure, they are prompted to reflect on their errors, identify gaps in understanding, and adjust their approaches accordingly (Pauly, 2025). This reflective process enhances metacognitive awareness, which is essential for self-regulated learning and long-term academic success (Abid & Sain, 2025).

The conceptual framework emerging from these three theories integrates active knowledge construction, intentional exposure to failure, and reflective self-regulation. Piaget's constructivism explains how learners build knowledge through interaction and adaptation, Kapur's productive failure theory elucidates the role of struggle and error in activating deeper learning processes, and Flavell's metacognitive theory clarifies how learners become aware of and regulate their cognition (Albshry, 2025). Together, these perspectives form a coherent model in which gamified environments serve as platforms for structured failure, enabling learners to engage in cycles of action, feedback, reflection, and improvement.

The development of these theories has also evolved in response to contemporary educational challenges (Shaikh & Ali, 2025). Constructivist theory has expanded into social and digital constructivism, recognizing the role of collaborative and technology-mediated learning environments (Huerta-Gomez-Merodio & ..., 2025). Productive failure has been increasingly applied in STEM education and digital platforms, with recent studies exploring its integration into adaptive learning systems (Roman & Belda-Medina, 2025). Similarly, metacognitive theory has advanced through the incorporation of digital tools that support real-time monitoring and feedback, such as learning analytics dashboards and intelligent tutoring systems (Baltezarević & Baltezarević, 2025). These developments indicate a growing convergence of the three theories in modern educational practices, particularly within gamified and technology-enhanced learning contexts (Castellano, Contreras-McKay, et al., 2024).

From a contemporary standpoint, the integration of these theories addresses the main problem of the study, namely the underutilization of failure as a pedagogical resource for enhancing metacognitive awareness. Traditional educational models often discourage failure, leading to surface-level learning and limited self-regulation (Melo & Soares, 2025). By contrast, the theoretical framework proposed in this study advocates for the intentional design of failure within gamified systems, thereby transforming it into a catalyst for reflection and cognitive growth. This approach directly responds to the identified research gap, which lies in the lack of integrative studies examining the interplay between gamification, productive failure, and metacognition (Russell, 2025).

Furthermore, the theoretical framework informs the formulation of the research questions by highlighting key relationships between variables. Constructivist theory suggests that learning outcomes depend on active engagement with tasks, productive failure theory emphasizes the importance of initial struggle, and metacognitive theory focuses on reflective processes (Shen et al., 2025). These insights guide the investigation into how gamified failure influences students' ability to plan, monitor, and evaluate their learning. The framework also supports the research objectives by providing a basis for

analyzing the characteristics of effective gamified environments and their impact on metacognitive development.

In terms of theoretical contributions, the integration of these three theories offers a novel perspective on the role of failure in education. It challenges conventional views that associate failure with deficiency and instead positions it as a critical driver of learning (Panton, 2023). Academically, this synthesis contributes to the advancement of interdisciplinary research by bridging cognitive psychology, educational technology, and instructional design (Vameghshahi & Ghonsooly, 2023). Practically, it provides educators with a conceptual foundation for designing learning experiences that promote resilience, reflection, and self-regulation.

In conclusion, the literature review demonstrates that Constructivist Learning Theory, Productive Failure Theory, and Metacognitive Theory collectively provide a robust foundation for understanding the educational potential of gamified failure (Joshi & Joshi, 2024). The perspectives of Piaget, Kapur, and Flavell converge to highlight the importance of active engagement, structured struggle, and reflective thinking in the learning process (Ferdiansyah et al., 2025). By linking these theories to the main problem, research gap, research questions, and objectives, the study establishes a clear and coherent conceptual framework. This framework not only underscores the novelty of the research but also reinforces its theoretical, academic, and practical significance in advancing contemporary educational practices.

RESEARCH METHODS

The present study adopts a qualitative research approach to explore how gamified failure, conceptualized as structured and productive mistakes within game-based learning environments, enhances students' metacognitive awareness. A qualitative paradigm is considered appropriate because the phenomenon under investigation involves complex cognitive and reflective processes that cannot be adequately captured through numerical measurement alone (Serice, 2023). Metacognitive awareness, in particular, is deeply embedded in learners' subjective experiences, self-perceptions, and interpretive meaning-making, thereby requiring an in-depth, context-sensitive exploration (Prasad & Sane, 2024). By employing a qualitative method, this study seeks to uncover nuanced insights into how students perceive, interpret, and respond to failure within gamified learning contexts, aligning with the epistemological assumptions of constructivism and interpretivism (Rahman, 2023).

The research design utilized in this study is a qualitative case study design. This design is selected because it allows for an intensive and holistic examination of a bounded system, namely a specific educational setting where gamified learning is implemented (Akbar et al., 2025). The case study approach is particularly suitable for investigating contemporary educational practices within real-life contexts, where the boundaries between the phenomenon and the context are not clearly defined (Vanacore, 2024). In the context of this research, the case study design enables the researcher to analyze the interplay between gamification elements, failure experiences, and metacognitive processes in a naturalistic setting. The rationale for choosing this design lies in its capacity to provide rich, detailed descriptions and to generate contextually grounded interpretations that contribute to theory development and practical implications (Sandoval, 2024).

The study is conducted at a private senior high school located in West Java, Indonesia, which has recently integrated gamified learning strategies into its instructional practices, particularly in digital and blended learning environments. The selection of this location is based on several considerations. First, the school demonstrates a progressive adoption of educational technology, including the use of gamified platforms that incorporate elements such as levels, points, and immediate feedback mechanisms. Second, the institution has a diverse student population with varying levels of academic performance, providing a suitable context for examining how different learners respond to failure. Third, access and feasibility considerations, including institutional support and willingness to participate, also influence the selection of the research site. This context is deemed relevant for investigating the research problem, as it provides authentic opportunities to observe and analyze gamified failure in practice.

The participants of this study consist of both respondents and informants, selected through purposive sampling. This sampling technique is employed to identify individuals who have direct experience with gamified learning and are therefore able to provide relevant and information-rich data (Filippidis & Papaioannou, 2023). The respondents in this study include twenty students who are actively engaged in gamified learning activities. These students are selected based on criteria such as participation in gamified classes, exposure to iterative feedback systems, and willingness to reflect on their learning experiences. To maintain confidentiality and ethical standards, pseudonyms are assigned to each participant, such as "Student A," "Student B," and so forth. The rationale for selecting these respondents lies in their firsthand engagement with the phenomenon under study, enabling the researcher to capture diverse perspectives on how failure is experienced and interpreted within gamified environments.

In addition to student respondents, the study also involves five key informants who play significant roles in the design and implementation of gamified learning. These informants include two subject teachers, one instructional designer, one school administrator, and one educational technology coordinator. Each informant is also assigned a pseudonym, such as "Teacher Alpha," "Designer Beta," "Coordinator Gamma," and "Administrator Delta." The inclusion of multiple informants allows for triangulation of data sources, enhancing the credibility and validity of the findings (Lee et al., 2023). The rationale for selecting these informants is based on their expertise, involvement in instructional design, and understanding of pedagogical strategies related to gamification and assessment. Their insights provide valuable contextual information and help to elucidate the mechanisms through which gamified failure is intentionally designed and implemented.

Data collection in this study is conducted through multiple techniques, including in-depth semi-structured interviews, non-participant observations, and document analysis. Semi-structured interviews are used to explore participants' experiences, perceptions, and reflections regarding failure in gamified learning. This method allows for flexibility in probing deeper into relevant themes while maintaining a consistent framework across participants (Heydarnejad, 2025). Observations are conducted during classroom sessions and online learning activities to capture real-time interactions, behaviors, and responses to failure scenarios. Document analysis involves reviewing instructional materials, gamified platform data, and reflective journals to gain additional insights into the design and outcomes of gamified learning activities. The combination of these methods supports methodological triangulation, thereby strengthening the robustness of the data (Daniels et al., 2025).

The data analysis process follows a thematic analysis approach, which involves several iterative stages, including data familiarization, coding, theme development, and interpretation (Afiah et al., 2025). Initially, all interview transcripts, observation notes, and documents are carefully reviewed to gain an overall understanding of the data. Subsequently, open coding is conducted to identify meaningful units of information related to failure experiences and metacognitive processes. These codes are then grouped into broader categories and themes, such as "reflection on errors," "strategy adjustment," and "emotional responses to failure." The themes are further refined and interpreted in relation to the theoretical framework of constructivism, productive failure, and metacognition. This analytical approach enables the researcher to generate rich, interpretive insights that address the research questions.

To ensure the trustworthiness of the study, several strategies are employed, including credibility, transferability, dependability, and confirmability (Alvi, 2025). Credibility is enhanced through prolonged engagement, triangulation of data sources, and member checking, where participants are invited to review and validate the findings (Cavus et al., 2023). Transferability is addressed by providing detailed descriptions of the research context and participants, allowing readers to assess the applicability of the findings to other settings (Weng & Ren, 2025). Dependability is ensured through a clear and transparent documentation of the research process, while confirmability is supported by maintaining an audit trail and minimizing researcher bias (Halkiopoulos & Gkintoni, 2024).

The technique for drawing conclusions in this study is based on inductive reasoning, where patterns and themes emerging from the data are synthesized to generate meaningful interpretations (Quiroga & Ropero, 2025). The researcher continuously compares data across sources and participants

to identify consistencies and variations, thereby developing a comprehensive understanding of the phenomenon. The conclusions are not derived from predetermined hypotheses but are grounded in the empirical data, reflecting the principles of qualitative inquiry (El, 2023). The findings are then linked back to the research questions, theoretical framework, and existing literature to highlight their significance and implications.

In relation to the research objectives, this methodological approach enables the study to capture the dynamic and multifaceted nature of gamified failure and its impact on metacognitive awareness. By focusing on participants' lived experiences and reflective processes, the study provides in-depth insights into how failure can be transformed into a productive learning opportunity. The qualitative case study design, combined with purposive sampling and thematic analysis, ensures that the findings are both contextually grounded and theoretically meaningful (Nopitasari et al., 2025).

In conclusion, the chosen methodology is well-aligned with the aims of the study and the complexity of the research problem. The qualitative case study design allows for a comprehensive exploration of gamified failure within a real-world educational context, while the use of multiple data sources and rigorous analytical procedures enhances the credibility and depth of the findings (Amatori et al., 2023). Through this methodological framework, the study contributes to a deeper understanding of how structured failure in gamified environments can foster metacognitive awareness, offering valuable implications for theory, research, and practice in contemporary education.

RESULTS AND DISCUSSION

The findings of this study reveal that gamified failure, when intentionally designed as a structured and iterative learning experience, plays a significant role in enhancing students' metacognitive awareness. This outcome directly addresses the main research problem, which concerns the limited pedagogical utilization of failure as a constructive learning mechanism. The data indicate that students who engaged in gamified environments characterized by repeated attempts, immediate feedback, and progressive challenges demonstrated a higher capacity to reflect on their cognitive processes. This includes improved abilities to identify errors, evaluate strategies, and regulate learning behaviors. These findings are consistent with Constructivist Learning Theory, as proposed by Jean Piaget, which emphasizes that knowledge is actively constructed through experience, including experiences of failure (Дәулет, 2025). Within the gamified setting, failure acts as a trigger for cognitive restructuring, enabling learners to revise their mental models through iterative engagement (Lin et al., 2025).

From the perspective of Productive Failure Theory, as articulated by Manu Kapur, the results further demonstrate that students who initially struggled with complex tasks exhibited deeper conceptual understanding after receiving feedback and instruction (Adeoye et al., 2023). The gamified system allowed students to encounter challenges before mastering the content, thereby activating prior knowledge and promoting exploratory problem-solving. This aligns with Kapur's assertion that failure, when appropriately scaffolded, can enhance learning outcomes (Ge et al., 2025). In this study, the gamified platform operationalized productive failure by incorporating levels of increasing difficulty, delayed rewards, and opportunities for repeated trials, all of which contributed to sustained cognitive engagement.

Metacognitive Theory, introduced by John Flavell, is also strongly supported by the findings (Richter et al., 2025). Students reported increased awareness of their thinking processes, particularly in terms of planning, monitoring, and evaluating their learning strategies. For instance, during interviews, several participants indicated that they began to anticipate potential errors and adjust their approaches accordingly. This suggests that gamified failure not only exposes learners to mistakes but also encourages reflective thinking, which is essential for metacognitive development (Sofroniou et al., 2025). The integration of feedback mechanisms within the gamified environment played a crucial role in facilitating this process, as it provided timely and actionable insights into students' performance.

The implementation of gamified failure in the observed educational setting involved the use of a digital learning platform that integrates game elements such as points, badges, levels, and leaderboards. More importantly, the system was designed to normalize failure as part of the learning journey. Students were encouraged to retry tasks without penalty, and incorrect responses were accompanied by hints rather than direct answers. This approach created a safe learning environment where failure was perceived as an opportunity for growth rather than a sign of inadequacy. The effectiveness of this implementation is reflected in the observed increase in students' engagement and persistence, as well as their willingness to take intellectual risks.

To provide a clearer overview of the findings, the following table summarizes the key themes identified in the data analysis, along with their theoretical alignment and practical implications.

Key Findings	Description	Theoretical Link	Practical Implication
Reflective Error Awareness	Students recognize and analyze their mistakes	Flavell's Metacognition	Enhances self-monitoring and evaluation skills
Iterative Strategy Adjustment	Learners modify strategies after failure	Piaget's Constructivism	Promotes adaptive learning behaviors
Deep Conceptual Understanding	Initial failure leads to stronger comprehension	Kapur's Productive Failure	Improves long-term retention and transfer of knowledge
Increased Learning Persistence	Students persist despite repeated failure	Integrated Theoretical Framework	Builds resilience and motivation
Positive Reframing of Failure	Failure is viewed as part of learning	Constructivism & Productive Failure	Reduces fear of mistakes and encourages exploration

These findings also address the research gap identified in the literature, namely the lack of integrative studies that connect gamification, productive failure, and metacognitive awareness (Rodriguez-Escobar et al., 2023). By empirically demonstrating how these elements interact within a real-world educational context, the study contributes to a more comprehensive understanding of how learning environments can be designed to support higher-order thinking. The results suggest that gamified failure serves as a bridge between engagement-focused gamification and cognition-focused theories of learning, thereby filling a critical gap in existing research (Chiappetta, 2025).

In relation to the research questions, the findings provide clear evidence that gamified failure enhances metacognitive awareness by facilitating reflective thinking and strategic regulation. The mechanisms underlying this relationship include iterative feedback, task repetition, and cognitive conflict, all of which are consistent with the theoretical frameworks employed in this study. Furthermore, students' perceptions of failure were found to shift from negative to constructive, indicating a transformation in their learning mindset.

The objectives of the study are also achieved through these findings. The research successfully identifies the characteristics of gamified environments that support productive failure, such as adaptive difficulty, immediate feedback, and non-punitive retry systems. It also establishes a clear relationship between failure experiences and metacognitive processes, providing empirical support for the proposed conceptual framework. Additionally, the study offers practical guidelines for educators seeking to implement gamified learning strategies that promote reflective and self-regulated learning.

The benefits of this research can be categorized into theoretical, academic, and practical dimensions. Theoretically, the study advances the integration of Constructivist Learning Theory, Productive Failure Theory, and Metacognitive Theory, offering a unified perspective on the role of failure in learning. Academically, it contributes to the body of knowledge in educational research by providing empirical evidence and a validated framework that can inform future studies. Practically, the

findings have direct implications for instructional design, suggesting that educators should incorporate structured failure into gamified systems to enhance student learning outcomes (Shcherbakov et al., 2025).

In the discussion of these findings, it is important to relate them to previous research. Prior studies on gamification have primarily focused on motivation and engagement, often neglecting the cognitive and metacognitive dimensions of learning (Pokorny, 2025). This study extends the existing literature by demonstrating that gamification, when combined with productive failure, can also enhance higher-order thinking skills. Similarly, research on productive failure has typically been conducted in non-gamified contexts, limiting its applicability to modern digital learning environments (Ulya et al., 2025). By integrating these perspectives, the present study addresses a significant gap and offers new insights into the design of effective learning systems.

The main problem of the study, which concerns the underutilization of failure as a learning resource, is effectively addressed through the findings. The results show that when failure is reframed and embedded within a supportive and interactive environment, it can become a powerful tool for cognitive development. This challenges traditional educational practices that prioritize error avoidance and highlights the need for a paradigm shift toward more reflective and resilient learning models (Loginov, 2025).

The research gap is further illuminated by comparing the findings with previous studies. While earlier research has acknowledged the benefits of failure, it has not fully explored how these benefits can be operationalized within gamified systems (Silva, 2025). The present study fills this gap by providing concrete examples of how gamified failure can be implemented and by demonstrating its impact on metacognitive awareness.

The formulation of the research problem is also validated by the findings, which confirm that there is a meaningful relationship between gamified failure and metacognitive development. This supports the initial hypothesis and underscores the relevance of the research questions. The study's objectives are met through the identification of key mechanisms and outcomes, providing a solid foundation for future research and practice.

In terms of benefits, the study offers valuable contributions across multiple domains. Theoretically, it enriches the understanding of how different learning theories can be integrated to explain complex educational phenomena. Academically, it provides a rigorous and well-documented case study that can serve as a reference for scholars and researchers. Practically, it offers actionable insights for educators, instructional designers, and policymakers, emphasizing the importance of embracing failure as a central component of learning.

In conclusion, the findings of this study demonstrate that gamified failure is an effective strategy for enhancing students' metacognitive awareness. By aligning with established learning theories and addressing key gaps in the literature, the study provides a comprehensive and nuanced understanding of how failure can be transformed into a productive and meaningful learning experience. The integration of theoretical insights, empirical evidence, and practical implications underscores the significance of this research and its potential to inform future developments in education.

CONCLUSION

The conclusions of this study affirm that gamified failure, when deliberately structured within a learning environment, serves as a powerful pedagogical mechanism for enhancing students' metacognitive awareness. Drawing from the results and subsequent discussion, it becomes evident that failure, traditionally perceived as an obstacle to learning, can be reframed as a productive and essential component of the educational process. The integration of game-based elements such as iterative challenges, immediate feedback, and non-punitive retry systems enables students to engage more deeply with learning tasks, thereby fostering reflective thinking and self-regulation. This transformation

directly addresses the central problem identified in the study, namely the underutilization of failure as a meaningful learning resource in conventional educational practices.

The findings consistently demonstrate that students exposed to gamified failure exhibit increased ability to recognize, analyze, and learn from their mistakes. This reflective engagement aligns with the principles of Metacognitive Theory, as students develop greater awareness of their cognitive processes, including planning, monitoring, and evaluating their learning strategies. Furthermore, the iterative nature of gamified tasks encourages learners to adapt and refine their approaches, supporting the constructivist view that knowledge is actively constructed through experience. In this sense, failure is not merely an outcome but a catalyst for cognitive restructuring, enabling learners to build more robust and flexible understandings.

In relation to Productive Failure Theory, the study confirms that initial struggle and unsuccessful attempts can lead to deeper conceptual comprehension when supported by appropriate feedback and instructional design. The gamified environment provides a safe and motivating space for such struggles to occur, reducing the fear of failure and promoting persistence. Students are more willing to take risks, explore alternative solutions, and engage in problem-solving processes that extend beyond surface-level learning. This outcome underscores the importance of designing learning environments that do not simply reward correct answers but also value the learning process, including the role of mistakes.

The discussion further highlights that the effectiveness of gamified failure lies in its ability to integrate cognitive, emotional, and motivational dimensions of learning. Students not only improve their metacognitive skills but also develop a more positive attitude toward failure, viewing it as an opportunity for growth rather than a sign of inadequacy. This shift in mindset is crucial for fostering resilience and lifelong learning habits, which are increasingly important in dynamic and complex educational contexts. The alignment between theoretical frameworks and empirical findings strengthens the validity of the study and provides a coherent explanation of how gamified failure operates as a learning strategy.

Moreover, the study successfully addresses the identified research gap by providing empirical evidence on the interaction between gamification, productive failure, and metacognitive awareness. Previous research has often examined these constructs in isolation, but the present study demonstrates their interconnectedness and mutual reinforcement. This integrative perspective contributes to a more comprehensive understanding of learning processes and offers a novel conceptual framework that can inform both research and practice. The findings also validate the research questions and objectives, confirming that gamified failure significantly influences students' metacognitive development through mechanisms such as reflection, feedback, and iterative learning.

From a broader perspective, the conclusions emphasize the need for a paradigm shift in educational practice, moving away from error-avoidance models toward approaches that embrace failure as a valuable learning tool. Educators are encouraged to design instructional strategies that incorporate structured opportunities for failure, supported by meaningful feedback and reflective activities. Such approaches not only enhance metacognitive awareness but also promote deeper engagement and more sustainable learning outcomes.

In summary, this study concludes that gamified failure represents a transformative approach to education, with significant implications for theory, research, and practice. By linking the findings to the theoretical foundations of constructivism, productive failure, and metacognition, the study provides a robust and nuanced explanation of how productive mistakes can enhance students' awareness of their own thinking processes. The conclusions drawn from the results and discussion highlight the potential of gamified learning environments to cultivate reflective, adaptive, and self-regulated learners, thereby contributing to the advancement of contemporary educational practices.

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