

Gamification in Ghanaian Mathematics Classrooms: Examining the Roles of Teacher Knowledge, Motivation, and Self-Efficacy in Student Engagement

Justice Dadzie¹, Ruth Keziah Anaan-Brew², Elizabeth Danso³

¹*The University of Alabama, US*

²*The University of Cape Coast, Ghana*

³*North Dakota State University, US*

ABSTRACT

This study explores how teachers' knowledge of gamification, motivation, and self-efficacy influences student engagement in junior high school mathematics classrooms in Ghana. Grounded in Bandura's social cognitive theory, Astin's involvement theory, and Tinto's interactionist theory, this research addresses the urgent need for engaging, student-centered instruction in underresourced settings. Using a cross-sectional design, we surveyed 155 mathematics teachers and analyzed the data via structural equation modeling. The results revealed that higher self-efficacy predicted greater gamification use, whereas motivation showed a surprising inverse relationship. Both motivation and knowledge of gamification boosted student engagement. These findings underscore the need for targeted teacher training, providing actionable insights to enhance mathematics education and improve learning outcomes through gamified instruction.

Keywords: Gamification; mathematics; student engagement; teacher motivation; teacher self-efficacy; performance

Editor: Artur Strzelecki, University of Economics in Katowice, Poland

INTRODUCTION

This study treats gamification as an active teaching strategy, placing it on equal footing with traditional methods such as discussion and question-and-answer techniques. In this context, a survey is used to evaluate teachers' familiarity with the implementation of gamification as a teaching and learning strategy. Gamification involves integrating game design elements into nongame contexts to enhance engagement, motivation, and learning outcomes, making it highly relevant to educational practices (Annan-Brew et al., 2023; Baral, 2025; Baral et al., 2025). Common game-like elements include awarding points and badges for task completion and milestone achievements, using leaderboards to foster healthy competition, and implementing levels or progression to maintain student interest and provide a sense of advancement. Challenges and quests actively transform learning into an interactive and contextually meaningful experience, whereas immediate feedback allows students to recognize and correct mistakes in real time, enhancing learning efficiency (Dichev & Dicheva, 2017; Annan-Brew et al., 2024). Storytelling and narratives also increase student engagement by making content more memorable and emotionally resonant (Kapp 2012; Dontoh et al., 2023). Although technology can support gamified learning environments, it is not a prerequisite. Simple adaptations such as converting a traditional quiz into a Jeopardy-style game can gamify instruction without advanced tools, fostering enjoyment and participation (Landers, 2014). These strategies demonstrate that effective gamification relies more on thoughtful design than on digital sophistication.

Mathematics stands as a cornerstone for nurturing logical thinking and cognitive abilities in students (Baral et al., 2025). Its significance extends beyond the classroom, influencing various scientific disciplines such as engineering, physics, and statistics (Ganal & Guiab, 2014; Dadzie & Annan-Brew, 2023). Despite its importance, many students perceive mathematics as daunting and uninteresting, a concern echoed in international assessments. Reports from the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) consistently reveal that a significant proportion of students demonstrate low interest and confidence in mathematics, often associated with anxiety and disengagement (OECD, 2019; Mullis et al., 2020). These findings underscore the pressing need for innovative instructional strategies, such as gamification, to transform the way students experience mathematics and promote deeper engagement. This perception often stems from negative experiences and anxiety developed during earlier academic years, leading to self-doubt and underperformance, especially among junior high school students (López-

Belmonte et al., 2020; Dadzie & Ahorsu-Walker, 2022; Kpodoe et al., 2023). Teachers must create a conducive learning environment where students can engage with mathematics positively. This requires not only a deep understanding of the subject but also the use of engaging, student-centered teaching methods to facilitate effective learning (Xi & Hamari, 2019). By embracing diverse instructional approaches and fostering a supportive atmosphere, teachers can empower students to overcome mathematics anxiety and thrive in their academic journeys.

The teaching and learning of mathematics have garnered significant attention from researchers, who are delving into both traditional and modern instructional approaches (Boaler, 2015; Radovic et al., 2017; Hiebert, 2007; Kapp, 2012; Landers, 2014). Scholars emphasize the significant role of students' attitudes, expectations, and emotions in influencing their performance in mathematics (Tran & Nguyen, 2021). Addressing students' motivational challenges has emerged as a critical concern in education (Rozhenko, 2021; Dadzie, 2022). Teachers today grapple with the task of adapting to the changing needs and preferences of learners, particularly those who have grown up in a digitally driven era (Chin & Fu, 2021). According to Ezugwu et al. (2024) and Dadzie et al. (2024), teachers with high subject matter expertise tend to exhibit increased self-efficacy and motivation, enabling them to engage students in the learning process effectively. However, past studies have shown that teachers frequently use only a narrow range of tactics to enhance students' involvement and achievement in mathematics (Huang et al., 2021; Amponsah et al., 2024; Baral, 2025; Baral et al., 2025). Motivated by innovative pedagogical approaches, there is a growing momentum in the development of new methods that inspire active participation and engagement among learners.

In the last few years, teachers have increasingly acknowledged the benefits of educational games in improving students' ability to remember information and develop problem-solving, communication, and teamwork skills. By integrating traditional game-based learning methods into mathematics classes, teachers can increase their confidence and enthusiasm, which in turn can positively affect how engaged and successful students are (Mohd et al., 2021). This method shows potential for addressing the difficulties that educational institutions encounter in encouraging student participation and involvement within the classroom setting (Lee & Hammer, 2011). The concept of "gamification" involves using elements of games in nongaming situations, such as educational environments (Manzano-León et al., 2021). When teachers incorporate elements and designs inspired by gamification into their traditional teaching approaches, they can craft engaging educational experiences that motivate students to actively participate in classroom activities (Manzano-

León et al., 2021; García-Hernández & González-Ramírez, 2021; Surman et al., 2024). However, it is important to recognize, as highlighted by Mora et al. (2017), that numerous gamification implementations are developed without a structured design process and may not consistently adhere to theoretical frameworks. As a result, the efficacy of gaming elements in these gamified applications may not consistently achieve their intended goals (Manzano-León et al., 2021; Surman et al., 2024).

Previous research has extensively documented the benefits of incorporating gamification in education, showing that it enhances students' communication with both peers and teachers, ultimately increasing their motivation to engage with course material (García-Hernández & González-Ramírez, 2021). Role-playing activities and other gamified learning experiences have been found to improve students' adoption of educational content while alleviating the stress associated with knowledge evaluation (Kirillov et al., 2016; Amponsah et al., 2024). Additionally, studies highlight that gamification can stimulate the release of neurotransmitters such as norepinephrine, epinephrine, and dopamine, which leads to feelings of enjoyment and greater openness to learning (Brull & Finlayson, 2016). These findings consistently demonstrate the positive impacts of gamification in classroom settings across various regions. However, the context in Ghana remains underexplored, particularly with respect to mathematics teachers' knowledge, self-efficacy, and use of gamification.

For example, research conducted in the United States and Europe has demonstrated that teachers with greater self-efficacy in using gamification are more likely to adopt innovative teaching methods, which in turn enhance student engagement and improve learning outcomes. Scager et al. (2017) reported that teachers who were confident in integrating game-based learning tools were significantly more likely to design interactive, student-centered classrooms. Similarly, Karamete (2024) reported that teacher self-efficacy in gamified instruction positively predicts both the frequency and quality of gamification use in European secondary schools. Other studies, such as those by Ertmer and Ottenbreit-Leftwich (2010) and Ifenthaler et al. (2012), also support the connection between teacher self-efficacy and the adoption of technology-enhanced pedagogies such as gamification.

Moreover, teachers in these studies reported feeling more confident in addressing student needs when gamification strategies were used, enhancing both the learning environment and student participation. These findings suggest that gamification not only supports student learning but also reinforces teachers' belief in their teaching capabilities, thereby improving overall classroom dynamics. In countries such as South Korea and Brazil, similar studies have shown that teachers with strong

self-efficacy are better equipped to use gamified tools, which leads to heightened student engagement, particularly in subjects perceived as difficult or disengaging (Karamert & Vardar, 2021; Monteiro et al., 2022; Dadzie et al., 2024). These findings highlight the critical role of teacher confidence in effectively implementing gamification to achieve positive educational outcomes. When teachers are confident in their ability to use gamification strategies, they are more likely to engage students and create a dynamic learning environment. This confidence not only enhances teachers' instructional practices but also positively impacts student motivation and learning experiences.

Research has consistently shown that the effectiveness of gamification depends not only on game mechanics but also on how teachers perceive, design, and implement these tools within their instructional environments. Papadakis (2020) demonstrated that when teachers use game development methods to introduce complex subjects such as programming, student comprehension and interest improve significantly when teachers receive appropriate training and support. Similarly, Papadakis et al. (2020) reported that educational games, when aligned with curricular goals, positively influence the learning process and student participation. Zourmpakis et al. (2023) extended this discussion by showing that adaptive gamification tailored to learners' contexts and needs boosts motivation and engagement more effectively than one-size-fits-all approaches do. These studies underscore the importance of teacher beliefs, technological readiness, and contextual adaptation in the successful adoption of gamification, particularly in underresourced educational systems. Integrating these perspectives enhances our understanding of the multifaceted role that teachers play in leveraging gamification to improve learning outcomes.

Ghana faces unique challenges in implementing gamification in education, particularly in junior high school mathematics. While global research has demonstrated the benefits of gamification, studies in Ghana have largely overlooked the role of teacher self-efficacy in this context. For example, Ofosu-Ampong et al. (2019) assessed teacher readiness for gamification, and Appiah et al. (2024) conducted a systematic review of gamification practices in education. However, neither study has examined how confident teachers feel in applying these strategies. Similarly, Opoku-Asare (2022) focused on gamification's potential to support environmental sustainability, and Akuetteh et al. (2023) explored its application in religious education. Although these studies demonstrate gamification's growing relevance across disciplines, they fail to address how teacher self-efficacy influences its effective implementation in the classroom.

Moreover, persistent underperformance in mathematics among junior high school students underscores the urgency for such interventions.

The West African Examinations Council (WAEC) reported that in 2021, only 35.7% of BECE candidates scored between grades A1 and C6 in mathematics, whereas more than 20% received grade F9, the lowest score (WAEC, 2021). The 2022 results showed a similar pattern, with mathematics continuing to record one of the highest failure rates (WAEC, 2022). These troubling outcomes call for targeted instructional reforms. To reverse this trend, educators must adopt innovative, student-centered approaches such as gamification. However, without building teachers' confidence and competence in using such tools, efforts to increase mathematics engagement and achievement may be limited (Adu-Gyamfi et al., 2023; Ampadu, 2017).

Recent international research has increasingly highlighted the transformative potential of gamification in education, particularly in enhancing student engagement and motivation through well-designed, interactive learning environments. Studies such as Papadakis et al. (2020) and Zourmpakis et al. (2023) have shown that integrating gamified elements into teaching practices can lead to meaningful learning gains, especially when adapted to students' needs. However, while these studies offer valuable insights from technologically advanced contexts, little is known about how such strategies function in low-resource settings such as Ghana.

This oversight revealed a significant gap in the literature. Given that teacher self-efficacy has been shown to strongly influence student engagement and learning outcomes in other countries (Aabeyir et al., 2025; Sicuan, 2025), exploring how this dynamic unfolds within the Ghanaian educational system is essential. The system faced persistent challenges, including large class sizes, limited technological access, and inadequate training in innovative teaching strategies such as gamification. Teachers often lack the technological proficiency necessary to implement gamified learning effectively, which in turn impacts student motivation and performance (Dadzie et al., 2024; Aabeyir et al., 2025).

This study responded to these challenges by investigating the knowledge, confidence, and motivation levels of junior high school mathematics teachers in Ghana regarding gamification. It also examined how these factors influenced their self-efficacy and the resulting engagement of their students. Previous research has shown that teachers with greater ICT competence are more likely to adopt gamified strategies successfully (Wilson et al., 2025; Yeboah et al., 2025). Despite rising interest in game-based learning, especially in mathematics, teachers' understanding of gamification as a pedagogical approach has remained limited. As such, this study aimed to generate practical insights for teacher development programs and policy initiatives aimed at strengthening both instructional quality and student achievement in the Ghanaian context.

Therefore, understanding the current state of teachers' knowledge and skills related to gamification is essential for addressing these gaps and improving mathematics education in Ghana. (1) To examine the nature of the relationship between teacher motivation and self-efficacy among junior high school mathematics teachers, (2) to investigate how teacher motivation and self-efficacy predict the level of knowledge in using gamification in the classroom, and (3) to investigate the individual and combined impacts of teachers' knowledge in the use of gamification, teachers' self-efficacy, and teachers' motivation on student engagement in junior high school mathematics education, (4) to explore the indirect influence of teachers' self-efficacy on both teachers' knowledge in the use of gamification and student engagement through the mediation of teachers' motivation, we developed the following research questions to steer our study.

This study seeks to investigate the impact of teachers' knowledge of gamification on their motivation, self-efficacy, and student engagement in the classroom. Building upon prior research, this study aims to answer four research questions:

Research Questions

1. What is the nature of the relationship between teacher motivation and self-efficacy among junior high school mathematics teachers?
2. How do teacher motivation and self-efficacy predict the level of knowledge in using gamification implementation in the classroom?
3. What are the individual and combined impacts of teachers' knowledge in the use of gamification, teachers' self-efficacy, and teachers' motivation on student engagement in junior high school mathematics education?
4. How does teachers' self-efficacy indirectly influence both teachers' knowledge of the use of gamification and student engagement through the mediation of teachers' motivation?

LITERATURE REVIEW

Theoretical Framework

Social Cognitive Theory (Bandura, 1997)

In the context of the study "Exploring the Impact of Gamification on Teacher Motivation, Self-Efficacy, and Student Engagement in Junior High School Mathematics Education," the theoretical foundation of self-efficacy draws from social cognitive theory, particularly emphasizing

individuals' control over their actions and outcomes (Bandura, 1997, 2006). Within this framework, teacher self-efficacy refers to teachers' confidence in their instructional practices, classroom management, and ability to engage students effectively (Zee & Koomen, 2016).

Teachers' confidence in their abilities plays a vital role, as it shapes how they teach, the effort they put in, and their determination to reach teaching goals (Bandura, 1997). Several factors, such as past experiences, observations of colleagues, feedback from others, and emotional well-being, can shape these beliefs (Oh, 2011). In our study, self-efficacy includes both the collective confidence shared among teaching groups, known as collective efficacy, and individual teachers' perceptions of how they influence student learning (Tschannen-Moran & Hoy, 2001).

Tschannen-Moran and Hoy (2001) noted three aspects of teacher self-efficacy: instructional techniques, student involvement, and classroom management. Teachers who possess strong self-efficacy demonstrate confidence in the use of successful teaching methods in these areas (Liu et al., 2020). As a result, their assurance has a positive effect on student learning results and their ability to handle classroom situations adeptly (Liu et al., 2020; Halim & Ahmad, 2015). Research indicates that teachers who have strong beliefs about their abilities are more likely to exhibit better instructional quality and employ student-centered teaching approaches (Butucha, 2014; Holzberger et al., 2013; Stronge, 2018).

Theories of Involvement (Astin's 1999) and the Interactionalist Theory of Student Departure (Tinto's 1975)

The concept of student engagement is rooted in Astin's (1999) theory of involvement and Tinto's (1975) interactionalist theory of student departure. Astin's theory highlights how much effort students put into their academic tasks, whereas Tinto's theory centers on how well students blend into school environments and educational tasks to improve their dedication and stay committed (Harper & Quaye, 2009). Originally developed to comprehend why students leave school prematurely, the concept of engagement has attracted considerable scholarly interest because of its positive links to several student outcomes, such as contentment, academic success, and social involvement (Ali & Hassan, 2018; Archambault et al., 2009; Kuh, 2009; Walker & Greene, 2009).

Fredricks et al. (2016) identified several key factors driving the growing interest in student engagement, including its strong link to academic achievement, its adaptability to teacher interventions, and its multifaceted structure encompassing behavioral, emotional, and cognitive components (Ben-Eliyahu et al., 2018; Fredricks et al., 2016). Researchers such as Appleton et al. (2006) have proposed various subcategories of

engagement to reflect its complexity and the need for more nuanced understanding. Despite its importance, studies report a steady decline in student engagement as learners progress through school, particularly during secondary education years (Martin & Torres, 2016). Teachers who offer consistent support and encouragement, along with collaborative efforts from the broader school community, significantly increase student engagement (Thien & Chan, 2022; Ali & Hassan, 2018). Nonetheless, researchers have largely overlooked student engagement in developing countries, highlighting an urgent need for further investigation in these contexts.

Self-Determination Theory of Motivation (Ryan and Deci 2000)

Self-determination theory (SDT), introduced by Ryan and Deci (2000), provides insights into human motivation by emphasizing three fundamental needs: autonomy, competence, and relatedness. Autonomy pertains to individuals having control over their actions and the freedom to make choices without feeling pressured, whereas competence refers to the sense of proficiency and capability in performing tasks and activities. Relatedness involves individuals feeling connected to others and recognized within social contexts. Ryan and Deci suggested that intrinsic motivation, which originates from within individuals, is more impactful in enhancing engagement and performance than extrinsic motivation, which comes from external factors.

However, Ryan and Deci propose that external incentives, such as rewards, have the potential to gradually nurture intrinsic motivation over time. Similarly, gamification, which employs external rewards such as students' achievements in mathematics, can initially spark teachers' interest and eventually foster intrinsic motivation for deeper engagement with subjects such as mathematics. Similarly, Gagné et al. (2015) emphasize the importance of attending to the needs for autonomy, competence, and relatedness to foster both intrinsic and extrinsic motivation. Recognizing the context and environment of individuals is vital for developing effective motivation strategies (Ruhi, 2015). Researchers, such as Dichev and Dicheva (2017), recognize self-determination theory (SDT) as essential for understanding the impact of teachers' motivation on gamification.

Empirical studies on gamification

Influence of Gamification in General

Gamification has extended its impact beyond the realm of education and is now being applied in diverse sectors such as business and health, garnering interest from professionals and scholars alike (Behl et

al., 2022). In the business sector, companies utilize gamification techniques such as human resource management and marketing to provide employee training, involve consumers, and induce behavioral shifts (Karakas & Alperen, 2012; Wunderlich et al., 2020). The attractiveness of gamification stems from its capacity to evoke enjoyment and fun, as highlighted by research conducted by Lu and Ho (2020) and Noorbehbahani et al. (2019).

In the healthcare field, gamification is instrumental in encouraging healthy lifestyles and addressing chronic diseases such as diabetes and hypertension, which are commonly associated with sedentary behavior and unhealthy eating habits, as emphasized by Sola et al. (2015). By harnessing the power of information and communication technology (ICT), particularly through gamification, interventions have been developed to promote lifestyle modifications and enhance health outcomes, as highlighted by Sola et al. (2015) and Rajani et al. (2021).

Influence of Gamification in Education

Teachers have widely adopted gamification in education to bolster student engagement, motivation, and performance, as noted by Hallifax et al. (2019), Saleem et al. (2022), and Zahedi (2019). Researchers in computer science have extensively explored various engagement techniques, with gamification emerging as a prominent approach, as highlighted by Zahedi (2019). Research has underscored the numerous advantages of incorporating games into teaching, including providing immediate feedback, offering personalized learning experiences, and fostering collaborative learning opportunities, as noted by Hallifax et al. (2019). Furthermore, Thurston (2018) identifies gamification as a transformative force in education, igniting greater student interest and involvement in learning activities.

Zirawaga et al. (2017) explored learning theories, including cognitive information processing and social activism, and discovered that students are motivated to participate in gamified courses, leading to increased confidence in their learning capabilities. Moreover, incorporating games into teaching can infuse excitement into otherwise dull instructional methods (Zirawaga et al., 2017; Hughey Surman et al., 2024). Furthermore, employing gamification for pedagogical purposes provides a sense of relief to students, who may encounter challenges with conventional teaching methods (Alsawaier, 2018). Nevertheless, despite the significant focus on gamification in education, its actual impact remains uncertain. Teachers and researchers continue to engage in a lively debate concerning the optimal timing, context, and methods for integrating gamification strategies into classroom settings (Van Roy & Zaman, 2018; R. Huang et al., 2020).

Influence of Teachers' Knowledge in Using Gamification on Their Motivation

Motivation acts as the fuel propelling individuals' interests and behaviors, whether instigated by external incentives such as rewards or by the intrinsic satisfaction derived directly from the activity at hand. Gamification, conceived initially to augment extrinsic motivation, is now acknowledged for its capacity also to increase intrinsic motivation. When teachers understand how to implement gamification effectively, they can transform the learning environment into a more dynamic and enjoyable space for students. This positive change can rekindle teachers' passion for teaching by providing them with innovative tools that make the educational process more rewarding and engaging. Moreover, seeing the tangible benefits of gamification, such as increased student participation, improved learning outcomes, and heightened interest in the subject matter, can serve as a powerful motivator for teachers.

A recent study conducted by Saleem et al. (2022) underscores the beneficial impact of gamification in education, highlighting its capacity to cultivate more immersive learning environments. Other researchers have supported these conclusions, affirming that gamification successfully motivates users to engage with educational systems (Bouchrika et al., 2021; Li et al., 2022). However, Ofose-Ampong et al. (2019) caution that merely integrating game elements may not lead directly to improved learning outcomes. They emphasize the importance of connecting gamified systems to teachers' motivations and behavioral intentions. Motivation, commonly seen as a key element in learning, is a complex concept shaped by cognitive, emotional, and environmental aspects. Although several theories attempt to explain motivation, none can comprehensively account for motivation across all situations. Reynolds and colleagues (2017) stress the link between motivation and learning, highlighting that while some aspects of motivation may enhance learning outcomes, not all aspects necessarily have a positive impact. In our study, titled "Exploring the perceived impact of gamification on teacher motivation, self-efficacy, and student engagement in junior high school mathematics education," we incorporated Ryan's self-determination theory to gain insights into how gamification affects teachers' motivation. According to Ryan's theory, individuals are motivated by their inherent desires for autonomy, competence, and relatedness. In this study, gamification likely met these needs by allowing teachers the freedom to design activities, boosting their sense of competence as they successfully implemented them, and fostering a sense of community through collaborative learning environments.

Although previous research has explored gamification's impact on teacher motivation, there remains a gap in understanding how it influences

specific factors that drive motivation. Building on the principles of self-determination theory, this study seeks to address this gap by identifying the essential factors that clarify how gamification influences teachers' motivation to engage students in learning.

Influence of Teachers' Knowledge in the Use of Gamification on Their Self-Efficacy

The influence of teachers' knowledge in the use of gamification on their self-efficacy is significant in the context of educational innovation. When teachers are well versed in the principles and techniques of gamification, they are more likely to feel confident in integrating these strategies into their teaching practices. This knowledge empowers them to create more engaging and interactive learning experiences, which can lead to improved student outcomes. As teachers see the positive impact of gamification on student engagement and achievement, their belief in their own ability to effectively manage and deliver instruction and self-efficacy naturally increases (Blohm & Leimeister, 2013). Consequently, teachers with higher levels of self-efficacy are more likely to continue exploring and adopting innovative teaching methods, creating a positive feedback loop that benefits both teachers and students.

In educational settings, gamified approaches harness elements from games, such as scoring systems, competition, and achieving objectives, to inspire and captivate students (Swacha, 2021). This method encourages interactive and engaging learning experiences, offering boundless possibilities limited only by the creativity of teachers. The effectiveness of gamification depends on the element of competition, whether it is challenging oneself or competing with peers, tapping into social dynamics and the drive for accomplishment (Hassan et al., 2021). External rewards, attainable through purposeful competition, have the potential to nurture the development of intrinsic motivation (Swacha, 2021). The incorporation of gamification into education encourages students to engage in healthy competition, which in turn cultivates a sense of self-efficacy and stimulates internal motivation. Consequently, this dynamic propels students toward learning and academic advancement (Hassan et al., 2021). As teachers, integrating gamified elements into teaching can cultivate dynamic learning environments that motivate students to engage actively and pursue academic excellence.

The Mediating Role of Teachers' Self-Efficacy and Motivation

Self-efficacy empowers teachers with a strong sense of confidence, allowing them to approach tasks with assurance and dedication. As emphasized by Chiang et al. (2022), accomplishing tasks successfully reinforces this confidence, driving qualitative improvements.

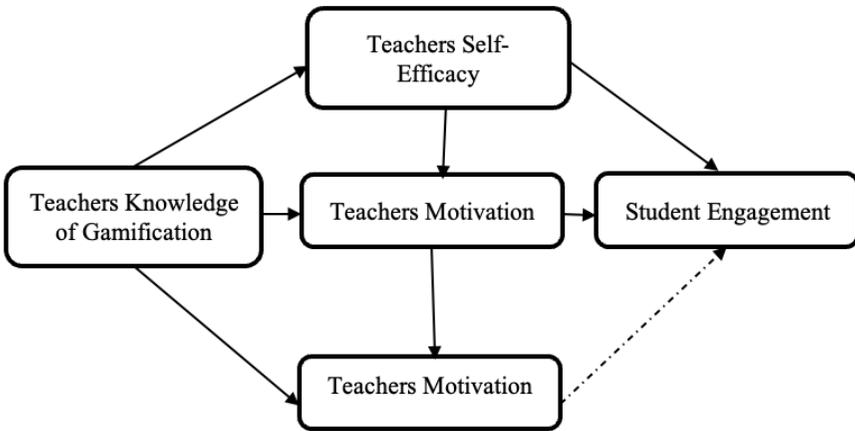
On the other hand, teachers with low self-efficacy may feel demotivated when faced with challenges, which can result in a cycle of decreasing confidence and performance setbacks. Moreover, there is a notable link between teachers' self-efficacy and their improvement in teaching methods and skills over time. Boosting self-efficacy positively impacts teaching methods, empowering teachers to attain superior professional results and exercise self-control. Teachers with high self-efficacy are inclined toward proactive decision-making, leading to a deeper understanding of the subject matter among junior high school mathematics teachers. This belief in their ability to effectively impart knowledge through persistent effort drives their commitment to excellence.

The incorporation of gamification into teaching fosters active student engagement, cultivates effective communication skills, and encourages a transformative shift in cognitive processes. Furthermore, teachers can find intrinsic motivation in the use of gamification, cultivating a favorable attitude toward its integration into teaching practices (Yu et al., 2022). This flexibility enables teachers to refine their teaching approaches continually, utilizing gamification as a tool to amplify student involvement and consequently increase academic achievement. Research findings consistently demonstrate that students exposed to gamified instructional methods outperform their peers educated through conventional approaches, highlighting the effectiveness of gamification in enriching educational achievements. As a result, teachers feel a sense of increased drive and satisfaction, deriving fulfillment from their innovative teaching strategies, diverse instructional concepts, dynamic learning environments, and collaborative teaching approaches. Additionally, the strong correlation observed between students' game scores and their end-of-semester test results highlights the competitive spirit fostered by gamification (Lera et al., 2022). This competitive edge not only enhances students' engagement but also ignites their enthusiasm for learning.

As illustrated in Figure 1, our proposed conceptual framework highlights the relationships among teachers' teacher knowledge of gamification and their self-efficacy, motivation, and student engagement in an educational context. The framework posits that teacher knowledge of gamification, defined as the integration of game-like elements into teaching, directly impacts teachers' self-efficacy and motivation. When teachers implement gamification strategies, they are likely to feel more capable and confident in their teaching abilities, which in turn enhances their self-efficacy. Furthermore, teachers' understanding of gamification can make the teaching process more enjoyable and rewarding, thereby increasing both their intrinsic and extrinsic motivation. Additionally, the framework suggests that teachers' self-efficacy directly influences student engagement. Teachers who believe in their capabilities are more inclined

to create dynamic and interactive learning environments that capture and sustain students' interest and enthusiasm. Therefore, by enhancing teachers' self-efficacy and motivation through gamification, the framework aims to ultimately boost student engagement, fostering a more effective and engaging learning experience.

Figure 1
Conceptual Framework



Note. A model exploring the impact of gamification on teachers' self-efficacy and motivation and subsequently on student engagement
Source: Authors' own construct (2024)

RESEARCH METHOD

The current study focused on mathematics teachers within the Mfantseman municipality, which was selected because of the consistently low student performance in mathematics. This municipality, characterized by its socioeconomic and educational diversity, includes a mix of public, private, and mission schools operated by Christian organizations, all of which present varying levels of resources and student outcomes. Out of a total of 870 teachers in the municipality, 158 are mathematics teachers, forming the accessible population for this research. These teachers were specifically targeted due to the poor mathematics performance observed in the 2021 and 2022 Basic Education Certificate Examinations (BECE), underscoring the need for focused interventions in this area. The diversity of the municipality ensures that the findings reflect the experiences of teachers in different educational contexts, making it an ideal location for study. Given the emphasis on mathematics teachers, purposive sampling

was employed to target only these teachers. The total number of mathematics teachers in the Mfantseman Municipality was 158, so we decided to include the entire population in the study. Cao et al. (2021) noted that a population size of 158 is sufficient for quantitative research. On this basis, we included all mathematics teachers in Mfantseman to ensure comprehensive and representative data collection.

A cross-sectional survey design was employed for this research; all 158 mathematics teachers were invited to participate after providing informed consent. Among those invited, 155 teachers agreed to take part, resulting in a final sample size of 155. Although the sample size of 155 may seem limited for SEM, it is defensible given the nature and scope of the study. First, several researchers have noted that PLS-SEM is suitable for exploratory research with small to medium sizes and can yield robust estimates even with fewer than 200 participants (Hair et al., 2011; Sarstedt et al., 2021). Moreover, according to Kline (2023), a minimum sample of 100–150 may be acceptable for SEM when the model involves a small number of indicators per latent variable and demonstrates adequate model fit. The present study employed validated instruments with strong psychometric properties and a theoretically grounded model with a manageable number of latent constructs and indicators, thereby reducing the likelihood of estimation issues. Additionally, Boomsma (1982) and Marsh et al. (1998) emphasized that model complexity, indicator reliability, and data quality are more critical than sample size in determining SEM adequacy. Therefore, the sample size of 155 is acceptable given the study's focus, model structure, and statistical techniques employed.

This census approach facilitated comprehensive data collection from all mathematics teachers in the municipality. The cross-sectional design was selected to capture a snapshot of the current understanding and practices related to gamification among mathematics teachers. This approach is ideal for examining the prevalence and distribution of characteristics within a defined population at a specific point in time. By involving all mathematics teachers in the municipality, the study ensures that the findings are comprehensive and representative, thereby enhancing the validity and generalizability of the results within this context. This design allows for a clear assessment of teachers' knowledge and attitudes toward gamification, providing valuable insights for future interventions and research.

Data collection instrument and procedure

To measure the key constructs in this study, several established scales were utilized to ensure both reliability and validity. Teachers' knowledge of gamification was assessed via a 5-item scale derived from

Liu et al. (2019), which focused on educational technologies and their classroom applications and was chosen for its relevance to the study's emphasis on gamification in teaching. Teachers' self-efficacy was evaluated with a 6-item scale from Speier and Frese (1997), which has been extensively validated in educational research and reliably assesses teachers' confidence in their teaching ability. Teacher motivation was measured via a 4-item scale developed by Botes et al. (2021), which encompasses both intrinsic and extrinsic motivational factors, to provide a comprehensive view of what drives teachers in their professional roles. Additionally, student engagement, a critical outcome linked to effective teaching, was measured via a 4-item scale adapted from Schaufeli et al. (2006), which is known for its comprehensive approach to assessing engagement across behavioral, emotional, and cognitive dimensions. The choice of these specific scales is grounded in their established reliability and validity, which has been rigorously tested in previous studies. This ensures that the constructs of teachers' knowledge of gamification, self-efficacy, motivation, and student engagement are accurately measured, allowing meaningful conclusions to be drawn.

To ensure data quality and integrity, we administered a structured paper-based survey in person at the participating schools across the Mfantseman Municipality. Trained research assistants distributed the questionnaires during scheduled professional development sessions or staff meetings, ensuring that all respondents had a quiet, uninterrupted environment for completion. We clearly explained the purpose of the study and guaranteed anonymity and confidentiality, which encouraged honest and thoughtful responses. To reduce response bias, we used validated scales with well-established psychometric properties and avoided leading or ambiguous items. We also conducted manual checks to identify and eliminate questionnaires that were incomplete or had inconsistent answers. These measures helped ensure the reliability and validity of the data used for the structural equation modeling and regression analyses.

Data analysis

We conducted data analysis via SmartPLS 4.0 and IBM SPSS AMOS 26.0. The analysis followed a two-step approach. First, we conducted exploratory factor analysis (EFA) in SPSS to identify the underlying factor structure of each construct and confirm item loadings. We used principal axis factoring with Promax rotation and retained factors with eigenvalues greater than 1. All factor loadings exceeded 0.60, and items with cross-loadings less than 0.30 were retained, supporting construct validity. Next, we employed confirmatory factor analysis (CFA) via AMOS to validate the measurement model. The CFA confirmed good model fit with acceptable indices (e.g., CFI > 0.90, RMSEA < 0.08, and

SRMR < 0.08), and all standardized loadings were above 0.60, supporting convergent validity. We further examined reliability via Cronbach's alpha and composite reliability (CR) and validity via the average variance extracted (AVE) and the Fornell–Larcker criterion to ensure discriminant validity. After confirming the measurement model, we used structural equation modeling (SEM) in AMOS to test the hypothesized relationships among the variables. The model included both direct and indirect pathways, as shown in the saturated and estimated path diagrams. Path analysis addressed the research questions and revealed distinct predictive pathways between teacher self-efficacy, motivation, gamification knowledge, and student engagement. To explore mediation, we used Sobel tests to assess indirect effects.

Ethical considerations

We adhered to all ethical standards for research involving human participants. Prior to data collection, we obtained ethical approval from the College of Education at the University of Cape Coast (Reference No. CES/IRB/UCC/EDU 108-23/3). All the participating mathematics teachers received detailed information about the study's purpose, procedures, and rights, including the right to withdraw at any point without penalty. Each participant provided written informed consent before participating in the study. Participation was entirely voluntary, and we ensured confidentiality by anonymizing all the responses throughout the data collection and analysis processes.

Measurement Model Evaluation

The reported values for Cronbach's alpha, composite reliability (ρ_a and ρ_c), and average variance extracted (AVE) were analyzed to evaluate the reliability and convergent validity of the constructs in this study. All the constructs presented Cronbach's alpha values that exceeded the recommended threshold of 0.70, indicating satisfactory internal consistency reliability. Specifically, the Cronbach's alpha values for teacher knowledge of gamification (KG), teacher self-efficacy (TSE), teacher motivation (TM), and student engagement (SE) were 0.816, 0.832, 0.866, and 0.874, respectively. Additionally, the composite reliability values (ρ_c) also surpassed the acceptable threshold of 0.70, further confirming the reliability of the constructs. The average variance extracted (AVE) values ranged from 0.559 to 0.672, with all values exceeding the minimum acceptable threshold of 0.50, although they varied slightly. Importantly, AVE values above 0.50 are generally considered acceptable for assessing convergent validity. Therefore, despite minor variability, the AVE values support the convergent validity of the constructs. Overall, considering the satisfactory Cronbach's alpha, composite reliability, and

AVE values, it can be concluded that the measurement model demonstrates adequate reliability and convergent validity. This suggests that the constructs reliably measure their respective latent variables (see Table 1).

Table 1

Measurement model evaluation-reliability and convergent validity

	Cronbach's alpha	Composite reliability (rho a)	Composite reliability (rho c)	Average variance extracted (AVE)
TKG	0.816	0.936	0.850	0.559
SE	0.832	0.981	0.867	0.621
TM	0.866	1.114	0.891	0.672

Discriminant validity

To evaluate discriminant validity, the correlation matrix between the constructs was analyzed. The diagonal elements of the matrix represent the square root of the average variance extracted (AVE) for each construct. These values should be greater than the correlations between the construct and any other construct in the matrix to ensure sufficient discriminant validity. In this analysis, the diagonal elements corresponding to Teacher Knowledge of Gamification (KG), student engagement (SE), teacher motivation (TM), and teacher self-efficacy (TSE) were approximately 0.748, 0.788, 0.820, and 0.780, respectively, as derived from the AVE values. A comparison of these diagonal values with the off-diagonal correlations revealed that all diagonal values exceeded the correlations between the constructs. For example, the correlation coefficient between KG and SE was 0.341, which was below the diagonal value of KG (0.748). Similarly, the correlations between KG and TM (0.273), KG and TSE (0.682), SE and TM (0.421), SE and TSE (0.225), and TM and TSE (0.526) were all lower than the corresponding diagonal values. This finding indicates that the constructs demonstrate sufficient discriminant validity, as the diagonal elements exceed the correlations with other constructs, supporting the distinction between the constructs in the analysis (see Table 2).

Table 2

Discriminant validity analysis-correlation matrix and diagonal values

	Teacher Knowledge of Gamification	Students Engagement	Teachers Motivation	Teachers Self- Efficacy
Teacher Knowledge of Gamification	1			
Students Engagement	0.341	1		
Teachers Motivation	0.273	0.421	1	
Teachers Self- Efficacy	0.682	0.225	0.526	1

Structural Model Results

The path coefficients in the model reveal the strength and direction of the relationships between the constructs. A positive coefficient between teacher knowledge of gamification (TKG) and teacher motivation (TM) suggests a modest positive relationship, indicating that as teachers' understanding of gamification increases, their motivation tends to rise slightly. Conversely, the strong positive coefficient between Teacher Knowledge of Gamification (TKG) and Teacher Self-Efficacy (TSE) underscores a significant relationship, indicating that as teachers become more knowledgeable about gamification, their confidence in using gamified techniques improves substantially. Moreover, the robust positive coefficient between teacher motivation (TM) and student engagement (SE) signifies a strong connection, suggesting that motivated teachers tend to foster higher levels of student engagement. However, the weak negative coefficient between teachers' self-efficacy (TSE) and student engagement (SE) presents a counterintuitive finding, implying a negligible decrease in student engagement as teachers' self-efficacy increases. These insights underscore the critical role of gamification knowledge in bolstering teachers' motivation and self-efficacy, ultimately influencing student engagement positively. Addressing these relationships can inform strategies to enhance teaching practices and student outcomes, such as providing targeted training to improve teachers' confidence in effectively utilizing gamification (see Table 3).

Table 3*Path coefficient analysis-relationships between constructs*

	Teacher Knowledge of Gamification	Students Engagement	Teachers Motivation	Teachers Self-Efficacy
Teacher Knowledge of Gamification			0.138	0.721
Students Engagement				
Teachers Motivation		0.618		
Teachers Self-Efficacy		-0.062		

Model Fit Indices

The comparison between the saturated model and the estimated model provides insights into the overall fit and predictive power of the structural model. Notably, the standardized root means square residual (SRMR) is utilized to assess the discrepancy between the observed and predicted correlation matrices. In this comparison, the saturated model has an SRMR of 0.175, whereas the estimated model has an SRMR of 0.198. Measures of discrepancy, including d_{ULS} and d_G , are also examined, with values of 5.806 and 4.712 for the saturated model, respectively, and 7.465 and 4.745 for the estimated model. The chi-square values for the saturated and estimated models are 1926.475 and 1956.744, respectively. Additionally, the normed fit index (NFI) is considered, yielding values of 0.352 for the saturated model and 0.342 for the estimated model. Furthermore, the R-square and adjusted R-square coefficients for each construct are analyzed to assess the predictive power, with values of 0.356 and 0.345 for SE, 0.019 and 0.011 for TM, and 0.520 and 0.516 for TSE, respectively. These values collectively provide a comprehensive evaluation of the model's fit and predictive capability (see Table 4).

Table 4

Comparison of Fit Indices between the Saturated and Estimated Models

	Saturated model	Estimated model
SRMR	0.175	0.198
d_{ULS}	5.806	7.465
d_G	4.712	4.745
Chi-square	1926.475	1956.744
NFI	0.352	0.342
	R-square	R-square adjusted
Students Engagement	0.356	0.345
Teachers Motivation	0.019	0.011
Teachers Self-Efficacy	0.520	0.516

RESULTS

Relationship between Teacher Motivation and Self-Efficacy in Junior High School Mathematics

Table 5

Correlation Analysis between Teachers' Self-Efficacy and Motivation

		Teachers Self-Efficacy	Teachers Motivation
Teachers Self-Efficacy	Pearson Correlation	1	.438
	Sig. (2-tailed)		.000
	N	155	155
Teachers Motivation	Pearson Correlation	.438	1
	Sig. (2-tailed)	.000	
	N	155	155

The correlation analysis presented in Table 5 illustrates a statistically significant positive correlation coefficient of 0.438 ($p < 0.001$) between teachers' self-efficacy and motivation, with a sample size of $N = 155$. This finding indicates a moderate positive relationship between teachers' self-efficacy and motivation. The coefficient of 0.438 suggests that there is a tendency for teachers reporting higher levels of self-efficacy to also report higher levels of motivation, and vice versa.

Figure 2

Path diagram for Predicting Teachers' Knowledge of Gamification Implementation through Teacher Motivation and Self-Efficacy



Table 6
Regression Weights

			Estimate	S.E.	C.R.	P	Label
Teachers Teacher Knowledge of Gamification	<-- -	Teachers Self Efficacy	.463	.057	8.147	.000	
Teachers Teacher Knowledge of Gamification	<-- -	Teachers Motivation	-.320	.080	-4.018	.000	

The results from structural equation modeling (SEM) analysis, as depicted in Table 6 and Figure 2, reveal significant relationships between teachers' self-efficacy, teachers' motivation, and the adoption of gamification in the classroom. The path coefficients indicate that teachers' self-efficacy has a positive and statistically significant association with the implementation of gamification techniques ($\beta = 0.463$, $p < 0.001$). This suggests that as teachers' self-efficacy increases, there is a corresponding increase in the utilization of gamification strategies within the teaching environment. In contrast, the analysis reveals a negative and significant relationship between teachers' motivation and the integration of gamification ($\beta = -0.320$, $p < 0.001$). This implies that higher levels of teachers' motivation are linked to lower levels of gamification incorporation in instructional practices. These findings underscore the interplay between teachers' beliefs regarding their instructional capabilities, their motivation levels, and the adoption of innovative teaching approaches such as gamification.

Figure 3

Path diagram of the impacts of teacher knowledge in gamification, self-efficacy, and motivation on student engagement in junior high mathematics

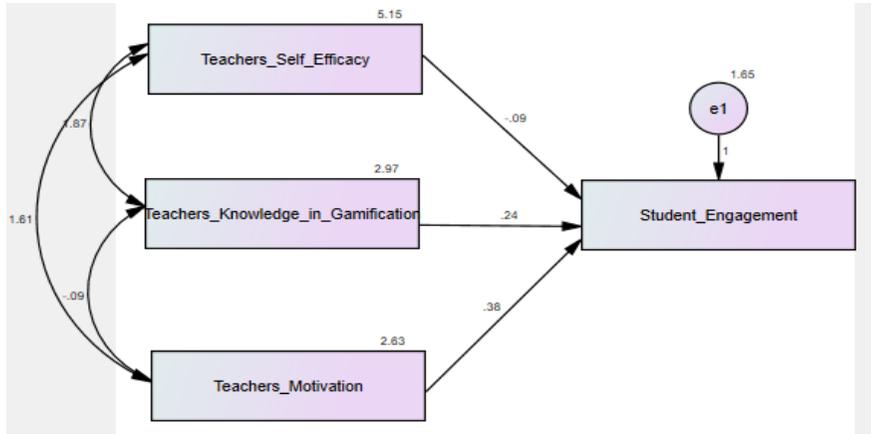


Table 7

Regression Analysis Results of the Impact of Gamification, Teachers' Self-Efficacy, and Teachers' Motivation on Student Engagement

			Estimate	S.E.	C.R.	P	Label
Student Engagement	<--	Teachers Knowledge of Gamification	.241	.072	3.355	.000	
Student Engagement	<--	Teachers Self Efficacy	-.088	.061	-1.450	.147	
Student Engagement	<--	Teachers Motivation	.375	.075	5.035	.000	

The regression analysis results reveal significant associations between student engagement and the predictor variables within the context of the study. Specifically, the regression weights indicate that gamification has a positive and statistically significant effect on student engagement (estimate = 0.241, SE = 0.072, CR = 3.355, $p < 0.05$), as evidenced by the standardized weight of 0.292. Furthermore, teachers' motivation also has

a notable positive effect on student engagement (estimate = 0.375, SE = 0.075, CR = 5.035, $p < 0.05$), with a standardized weight of 0.428. However, the relationship between teachers' self-efficacy and student engagement appears to be nonsignificant (estimate = -0.088, SE = 0.061, CR = -1.450, $p = 0.147$), as indicated by the standardized weight of -0.140. The equation representing the relationship between the predictor variables (gamification, teachers' self-efficacy, and teachers' motivation) and student engagement can be expressed as follows:

$$\text{Student Engagement} = 6.873 + 0.241\text{Gamification} - 0.088\text{Teachers Self-Efficacy} + 0.375\text{Teachers Motivation}$$

This equation illustrates the combined influence of gamification, teachers' self-efficacy, and teachers' motivation on student engagement, as determined by regression analysis.

Indirect Influence of Teacher Self-Efficacy on Gamification Knowledge and Student Engagement via Motivation

Table 8
Sobel Test Results for the Indirect Effects of Teachers' Self-Efficacy on Gamification and Student Engagement through Teachers' Motivation

Model		Indirect Effect	SE of Indirect Effect	of Sobel Test Statistic	P Value
Teachers Knowledge of Gamification Model	Teacher	.15	.07	4.51	<.001
Students Engagement Model	Engagement	.01	.07	.65	.513

Table 8 presents the results of the Sobel test conducted to investigate the indirect effects of teachers' self-efficacy on gamification and student engagement through teachers' motivation. In the gamification model, the Sobel test revealed a significant indirect effect of teachers' self-efficacy on gamification through

teachers' motivation (Sobel = 4.514, $p < .001$). However, in the student engagement model, the Sobel test indicated that the indirect effect of teachers' self-efficacy on student engagement through teachers' motivation was not significant (Sobel = 0.654, $p = .513$). These findings suggest that while teachers' self-efficacy significantly influences gamification through teachers' motivation, it does not have a significant indirect effect on student engagement through the same pathway.

DISCUSSION AND CONCLUSIONS

The interpretation of these findings must be understood within the broader context of Ghana's educational challenges, particularly in mathematics instruction at the junior high school level. Many schools face large class sizes, limited access to teaching and learning resources, and a lack of professional development opportunities focused on innovative pedagogy. These systemic issues often constrain teachers' ability to implement student-centered approaches such as gamification, regardless of their motivation or confidence. As highlighted in national assessment reports, persistent underperformance in mathematics continues to undermine student progression and academic confidence (WAEC, 2021; 2022). Within this environment, teacher self-efficacy and targeted training in gamified instruction become critical levers for change. Understanding these challenges not only frames the significance of the current study but also emphasizes the urgent need for scalable, low-cost pedagogical solutions that empower teachers in resource-constrained settings.

Relationship between Teacher Motivation and Self-Efficacy in Junior High School Mathematics

This finding is consistent with prior research emphasizing gamification's ability to enhance intrinsic motivation and classroom participation (Bouchrika et al., 2021; Li et al., 2022). These studies emphasize how gamification effectively engages users and enhances motivation by tapping into both extrinsic and intrinsic motivational factors. However, the caution raised by Ofofu-Ampong et al. (2019) regarding the necessity of linking gamified systems to students' motivations and intentions is also relevant here. While gamification can be a powerful tool for motivation, its effectiveness may vary depending on how well it addresses individuals' underlying motivational needs. Moreover, the study's focus on the correlation between teachers' self-efficacy and motivation is crucial, as it contributes to our understanding of the motivational determinants influenced by gamification. The moderate

positive correlation coefficient of 0.438 indicates that teachers with higher levels of self-efficacy also tend to exhibit higher levels of motivation, and vice versa.

This finding underscores the interplay between teachers' beliefs in their instructional abilities and their motivation to engage in teaching practices. Linking these findings to the theoretical frameworks of self-efficacy and student engagement, drawn from social cognitive theory and Astin's (1999) theory of involvement and Tinto's (1975) interactionist theory of student departure, respectively, further strengthens the study's contribution. The positive correlation between teachers' self-efficacy and motivation aligns with social cognitive theory, which emphasizes individuals' beliefs in their ability to exert control over their actions and the environment. Additionally, the study's exploration of how gamification influences student engagement indirectly through teachers' motivation and self-efficacy resonates with Astin's and Tinto's theories, highlighting the complex interplay between motivational factors and student outcomes in educational settings.

Predicting Teachers' Knowledge of Gamification Implementation through Teachers' Motivation and Self-Efficacy

The findings of the current study align with existing research on the positive influence of gamification on motivation in educational settings, as emphasized by Saleem et al. (2022), Bouchrika et al. (2021), and Li et al. (2022). These studies underscore how gamification effectively engages learners and enhances motivation by tapping into both extrinsic and intrinsic motivational factors. However, it is crucial to emphasize the caution raised by Oforu-Ampong et al. (2019) regarding the necessity of aligning gamified systems with students' motivations and intentions to optimize learning outcomes. Motivation, which is multifaceted and influenced by various factors, plays a pivotal role in learning processes. While the current study integrates Ryan's self-determination theory to understand how gamification influences teachers' motivation, its findings suggest a nuanced relationship between motivation, self-efficacy, and the adoption of gamification strategies in the classroom.

A central and unexpected finding in this study is the negative relationship between teacher motivation and the use of gamification. While initially counterintuitive, this result reflects a growing body of research that reveals motivational paradoxes in educational innovation. Motivated teachers may rely heavily on traditional or personally validated methods, viewing gamified strategies as disruptive or misaligned with their established instructional practices (Ertmer & Ottenbreit-Leftwich, 2010). Moreover, research shows that motivation alone does not guarantee innovation adoption; implementation depends on contextual fit, perceived

value, and usability of the method. For example, Papadakis et al. (2020) demonstrated that while educational games enhance engagement, their integration requires clear instructional alignment and teacher training. Similarly, Zourmpakis et al. (2023) reported that adaptive gamification improved student motivation only when teachers tailored game elements to specific learning needs, highlighting that mere enthusiasm is insufficient without implementation support. Teachers operating in low-resource contexts such as Ghana may feel motivated but constrained by systemic issues, such as limited access to technology, rigid curricula, or a lack of professional development, making them hesitant to adopt gamified instruction despite their overall drive. These findings suggest that motivation must align with feasibility and perceived pedagogical value, reinforcing the need for deeper training and contextual adaptation in gamification efforts.

Impact of Teacher Knowledge in Gamification, Self-Efficacy, and Motivation on Student Engagement in Junior High Mathematics

The discussion of the study reveals intriguing insights into the relationships among gamification, teacher motivation, self-efficacy, and student engagement. The findings align with the theoretical underpinnings of social cognitive theory, which posits that individuals' beliefs in their capabilities (self-efficacy) influence their motivation and behavior. As indicated by Chiang et al. (2022), teachers with higher self-efficacy are more likely to exhibit proactive decision-making and persistence in overcoming challenges, ultimately enhancing their teaching effectiveness. This concept resonates with our study's findings, which suggest a positive association between teacher motivation and student engagement, underscoring the importance of teachers' belief in their ability to foster engaging learning environments.

Moreover, the integration of gamification emerges as a significant factor in stimulating student engagement, supporting previous research on the positive impact of gamified methods on learning outcomes. The theory of involvement by Astin (1999) emphasizes the importance of student engagement in academic success, highlighting the role of innovative teaching approaches such as gamification in promoting active participation and enthusiasm for learning. Our regression analysis further reinforces these findings, revealing a significant positive effect of gamification on student engagement, which is in line with Astin's theory.

However, the nonsignificant relationship between teachers' self-efficacy and student engagement warrants further exploration. While social cognitive theory suggests that self-efficacy should positively influence behavior and outcomes, our findings suggest a lack of direct impact on student engagement. This unexpected discrepancy underscores

the complexity of the educational landscape, where myriad factors intersect to influence student learning experiences. To address this complexity, future research endeavors should delve into the multifaceted nature of teacher–student interactions, drawing on theoretical frameworks such as Tinto's interactionalist theory of student departure. By exploring the interplay between institutional structures, interpersonal dynamics, and instructional strategies, researchers can shed light on the nuanced pathways through which teachers' self-efficacy beliefs shape student engagement and academic success. We can advance our understanding of the factors driving effective teaching and learning practices, ultimately enhancing educational outcomes for all learners.

Indirect Influence of Teacher Self-Efficacy on Gamification Knowledge and Student Engagement via Motivation

The findings of the present study align with existing research on the pivotal role of self-efficacy in empowering teachers and promoting innovative teaching approaches. Consistent with the findings of Chiang et al. (2022), our study confirms that self-efficacy plays a crucial role in shaping teachers' confidence levels and their ability to navigate challenges effectively. High levels of self-efficacy among junior high school mathematics teachers are associated with proactive decision-making and continuous skill enhancement, contributing to improved teaching methodologies and better professional outcomes. These findings are in line with Bandura's (1977) social cognitive theory, which emphasizes the influence of self-belief on behavior and performance.

Furthermore, the integration of gamification in teaching is found to stimulate student engagement and foster intrinsic motivation among teachers. This resonates with the observations of Yu et al. (2022), highlighting how gamification can inspire teachers to adopt innovative teaching methods and continuously adapt their pedagogical approaches to enhance student learning experiences. Our study corroborates empirical evidence demonstrating the positive impact of gamification on student outcomes, as indicated by the significant correlation between game scores and end-of-semester test scores. The competitive learning environments facilitated by gamification contribute to increased student engagement and enthusiasm for learning, which aligns with Astin's (1999) theory of involvement and Tinto's (1975) interactionalist theory of student departure.

Regarding the Sobel test results, our findings reveal a significant indirect effect of teachers' self-efficacy on gamification through teachers' motivation, underscoring the importance of self-efficacy in driving teachers' motivation to adopt gamified teaching approaches. However, the absence of a statistically significant indirect effect on student engagement

through the same pathway suggests that other factors may play a more prominent role in influencing student engagement. While this result contrasts with some prior research, it highlights the nuanced nature of the relationship between motivational determinants and student outcomes, prompting further exploration in future studies. Overall, the current study contributes valuable insights into the complex dynamics of teacher motivation, self-efficacy, and the integration of gamification in educational settings, providing a foundation for future research in this area.

This study contributes new knowledge to the literature by empirically demonstrating how teacher self-efficacy, motivation, and teacher knowledge of gamification interact to influence student engagement in junior high school mathematics, an area previously underexplored in the Ghanaian context. While global studies have affirmed the value of gamification and teacher self-efficacy separately, this research is among the first to examine their combined and mediated effects within a Sub-Saharan African educational setting via structural equation modeling. Specifically, the finding that teacher self-efficacy positively predicts gamification knowledge and that motivation partially mediates this relationship adds nuance to social cognitive theory as applied to gamified pedagogy. Additionally, the surprising negative relationship between motivation and gamification challenges assumptions in the current gamification literature and raises new questions about motivational dynamics in resource-constrained environments. By addressing gaps related to teacher readiness, confidence, and pedagogical innovation in low-resource settings, this study provides a theoretical and practical foundation for teacher development programs and guides future research toward context-sensitive models of gamification adoption in education.

THEORETICAL CONTRIBUTION

The theoretical contribution of this study lies in its exploration of the relationships among teacher motivation, self-efficacy, teacher knowledge of gamification, and student engagement in junior high school mathematics education. By drawing on Bandura's social cognitive theory, Astin's theory of involvement, and Tinto's interactionist theory of student departure, this study provides a comprehensive framework for understanding how these factors interact with and influence each other. Additionally, the study highlights the need for further research to delve into the multifaceted nature of teacher–student interactions and the nuanced pathways through which teachers' self-efficacy beliefs shape student engagement and academic success. This study aims to advance our

understanding of effective teaching and learning practices, ultimately enhancing educational outcomes for all learners.

IMPLICATIONS

The findings of this study have important implications beyond the Ghanaian context, particularly for other low-resource educational settings globally. Many countries in Sub-Saharan Africa, Southeast Asia, and parts of Latin America face similar challenges: limited access to technology, large class sizes, and insufficient teacher training in innovative pedagogies. By demonstrating that teacher self-efficacy and knowledge of gamification significantly influence student engagement, even in resource-constrained environments, this study provides evidence that investing in teacher confidence and instructional innovation can yield meaningful improvements in student outcomes. The unexpected negative relationship between motivation and gamification use also highlights the need for context-sensitive approaches, suggesting that motivation alone may not translate into innovation without the right structural support. As such, this research contributes to the global discourse on equitable and effective teaching strategies by offering insights that can inform policy and practice in comparable educational systems worldwide.

The research findings have several implications for teachers, highlighting the need to increase self-efficacy through targeted professional development. For policymakers, this study supports the integration of gamification training in teacher education. Researchers should further explore the contextual barriers that moderate gamification's effectiveness in low-resource settings.

REFERENCES

- Aabeyir, B., Aabeyir, R., Amoako, S., & Boateng, F. O. (2025). Technology Acceptance and Self-Directed Learning: Mediation Role of Positive Emotions, Learning Motivation and Technological Self-Efficacy. *International Journal of Mathematics and Mathematics Education*, 3(1), 47-67.
<https://doi.org/10.56855/ijmme.v3i1.1178>
- Akuetteh, A. P., Kolog, E. A., Boateng, R., & Egala, S. B. (2023). Fit and Viable Determinants of Gamification in Christian Religious Studies in Developing Economy Context. *Journal of religion, media and digital culture*, 12(2-3), 160-184.
<https://doi.org/10.1163/21659214-bja10101>

- Ali, M. M., & Hassan, N. (2018). Defining concepts of student engagement and factors contributing to their engagement in schools. *Creative Education, 9*(14), 2161. <https://doi.org/10.4236/ce.2018.914157>
- Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology, 35*(1), 56-79. <https://doi.org/10.1108/IJILT-02-2017-0009>
- Amponsah, M. O., Ampofo, K. A., Annan-Brew, R. K., & Dadzie, J. (2024). Academic resilience and academic engagement as predictors of academic burnout among postgraduate students at the University of Cape Coast, Ghana. *Ghana (February 07, 2024)*. <https://doi.org/10.6017/ijahe.v10i3.17959>
- Annan-Brew, R. K., Ezugwu, I. J., Surman, S. H., & Dadzie, J. (2024). Enhancing pre-service teacher effectiveness: Integration of 21st-century skills during off-campus teaching experiences. *European Journal of Education, e12737*. <https://doi.org/10.1111/ejed.12737>
- Annan-Brew, R., Mensah, J. K., Ntim, E. K., Dadzie, J., Kpodoe, I. A., Akai-Tetteh, V. A., ... & Ampofo, K. A. (2023). Emotional reactions and burnout of instructors teaching wards with exceptional needs in inclusive schools in Offinso municipality: Moderating roles of coping mechanisms. *Creative Education, 14*(3), 487-507. <https://doi.org/10.4236/ce.2023.143034>
- Appiah, E., Essel, H. B., Anane-Antwi, E., & Boakye, A. A. (2024). Gamification in educational space: A systematic review. *Journal of Science and Technology (Ghana), 42*(2), 157-171. <https://doi.org/10.4314/just.v42i2.10>
- Appleton, J. J., Christenson, S. L., Kim, D., & Reschly, A. L. (2006). Measuring cognitive and psychological engagement: Validation of the Student Engagement Instrument. *Journal of school psychology, 44*(5), 427-445. <https://doi.org/10.1016/j.jsp.2006.04.002>
- Archambault, I., Janosz, M., Fallu, J. S., & Pagani, L. S. (2009). Student engagement and its relationship with early high school dropout. *Journal of adolescence, 32*(3), 651-670. <https://doi.org/10.1016/j.adolescence.2008.06.007>
- Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development, 40*(5), 518-529. <https://doi.org/10.1016/j.adolescence.2008.06.007>
- Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191-215. <https://doi.org/10.1037/0033-295X.84.2.191>

- Bandura, A. (2006). Toward a psychology of human agency. *Perspectives on psychological science*, 1(2), 164-180. <https://doi.org/10.1111/j.1745-6916.2006.000>
- Baral, D. (2025). Leveraging AI, magic, and field trips to prevent math anxiety in elementary school pupils. *American Journal of STEM Education*, 9, 21-34. <https://doi.org/10.32674/rxaamv34>
- Baral, D., Dasgupta, N., McLeman, L., Bista, R., Jones, J., & Biswakarma, M. (2025). Exploring the predictive relationship between students' math anxiety and their mathematical performance. *American Journal of STEM Education*, 3, 1-15. <https://doi.org/10.32674/c9zg4c28>
- Behl, A., Jayawardena, N., Pereira, V., Islam, N., Del Giudice, M., & Choudrie, J. (2022). Gamification and e-learning for young learners: A systematic literature review, bibliometric analysis, and future research agenda. *Technological Forecasting and Social Change*, 176, 121445. <https://doi.org/10.1016/j.techfore.2021.121445>
- Ben-Eliyahu, A., Moore, D., Dorph, R., & Schunn, C. D. (2018). Investigating the multidimensionality of engagement: Affective, behavioral, and cognitive engagement across science activities and contexts. *Contemporary educational psychology*, 53, 87-105. <https://doi.org/10.1016/j.cedpsych.2018.01.002>
- Blohm, I., & Leimeister, J. M. (2013). *Gamification: design of IT-based enhancing services for motivational support and behavioral change*. *Bus Inf Syst Eng* 5: 275–278. <https://doi.org/10.1007/s12599-013-0273-5>
- Boaler, J. (2015). *Mathematical Mindsets: Unleashing Students' Potential through Creative*. (1. Edition). PB printing.
- Boomsma, A. (1982). The robustness of LISREL against small sample sizes in factor analysis models. *Systems under indirect observation: Causality, structure, prediction*, 149-173. <https://cir.nii.ac.jp/crid/1570009750182746368>
- Botes, E., Dewaele, J. M., & Greiff, S. (2021). The development and validation of the short form of the foreign language enjoyment scale. *The Modern Language Journal*, 105(4), 858-876. <https://doi.org/10.1111/modl.12741>
- Bouchrika, I., Harrati, N., Wanick, V., & Wills, G. (2021). Exploring the impact of gamification on student engagement and involvement with e-learning systems. *Interactive Learning Environments*, 29(8), 1244-1257. <https://doi.org/10.1080/10494820.2019.1623267>
- Brull, S., & Finlayson, S. (2016). Importance of gamification in increasing learning. *The Journal of Continuing Education in*

- Nursing*, 47(8), 372-375. <https://doi.org/10.3928/00220124-20160715-09>
- Butucha, K. (2014). Relationships between secondary school beginning teachers' perceptions of self-efficacy and professional commitment in Ethiopia. *International Journal of Academic Research in Progressive Education and Development*, 3(3), 79-104. <http://dx.doi.org/10.6007/IJARPED/v3-i3/955>
- Cao, Y., Zhang, S., Chan, M. C. E., & Kang, Y. (2021). Postpandemic reflections: Lessons from Chinese mathematics teachers about online mathematics instruction. *Asia Pacific Education Review*, 22, 157-168. <https://doi.org/10.1007/s12564-021-09694-w>
- Chen, C. M., Li, M. C., & Chen, T. C. (2018, July). A collaborative reading annotation system with gamification mechanisms to improve reading performance. In *2018 7th International Congress on Advanced Applied Informatics (IIAI-AAI)* (pp. 188-193). IEEE. <https://doi.org/10.1109/IIAI-AAI.2018.00044>
- Chiang, F. K., Zhang, Y., Zhu, D., Shang, X., & Jiang, Z. (2022). The influence of online STEM education camps on students' self-efficacy, computational thinking, and task value. *Journal of science education and technology*, 31(4), 461-472. <https://doi.org/10.1007/s10956-022-09967-y>
- Chin, K. E., & Fu, S. H. (2021). Exploring the Implementation of an Intervention for a Pupil with Mathematical Learning Difficulties: A Case Study. *Journal on Mathematics Education*, 12(3), 531-546. <https://doi.org/10.22342/jme.12.3.14473.531-546>
- Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of applied psychology*, 78(1), 98-104. <https://doi.org/10.1037/0021-9010.78.1.98>
- Dadzie, J. (2022). *Teachers' and Students' Perceptions of the Effectiveness of Strategies Adopted in Curbing Exam Misconduct at Senior High Schools in the Sekondi takoradi Metropolis* (Doctoral dissertation, University of Cape Coast).
- Dadzie, J., & Ahorsu-Walker, J. (2022). Strategies for curbing examination malpractices: A mediating role of gender. *International Journal of Research and Innovation in Social Science*, 6(11), 379-385.
- Dadzie, J., & Annan-Brew, R. (2023). Strategies for curbing examination malpractices: Perspectives of teachers and students. *Global Journal of Social Sciences Studies*, 9(1), 1-14. <https://doi.org/10.55284/gjss.v9i1.842>
- Dadzie, J., Surman, S. H., Annan-Brew, R. K., and Ezugwu, I. J. (2024). Exploring the correlation between students' performance in educational statistics and research methods in education: The

- influence of undergraduate programs. *African Educational Research Journal*, 12(4): 337-347.
<https://doi.org/10.30918/AERJ.124.24.031>
- Dadzie, J., Surman, S. H., Annan-Brew, R. K., Ezugwu, I. J., Amponsah, N., & Addison, E. (2024). DOES ASSESSMENT QUALITY AND ASSESSMENT LITERACY INFLUENCE STUDENTS'ACADEMIC PERFORMANCE?. *European Journal of Education Studies*, 11(4).
<http://dx.doi.org/10.46827/ejes.v11i4.5265>
- Deci, E. L., & Ryan, R. M. (2000). The " what" and" why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, 11(4), 227-268.
https://doi.org/10.1207/S15327965PLI1104_01
- Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International journal of educational technology in higher education*, 14, 1-36. <https://doi.org/10.1186/s41239-017-0042-5>
- Dimopoulou, E. (2014). Self-efficacy and collective efficacy beliefs in relation to position, quality of teaching and years of experience. *Literacy Information and Computer Education Journal*, 5(1), 1467-1475. <https://doi.org/10.20533/licej.2040.2589.2014.0196>
- Dontoh, J., Annan-Brew, R. K., Kpodoe, I. A., & Dadzie, J. (2023). Navigating academic integrity in the digital era: Challenges, strategies, and solutions. *Journal of Education and Practice*, 14(25), 37-42.
- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of research on Technology in Education*, 42(3), 255-284. <https://doi.org/10.1080/15391523.2010.10782551>
- Fadhli, M., Brick, B., Setyosari, P., Ulfa, S., & Kuswandi, D. (2020). A meta-analysis of selected studies on the effectiveness of gamification method for children. *International Journal of Instruction*, 13(1). http://e-iji.net/dosyalar/iji_2020_1_54.pdf
- Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2016). Student engagement, context, and adjustment: Addressing definitional, measurement, and methodological issues. *Learning and instruction*, 43, 1-4.
<https://doi.org/10.1016/j.learninstruc.2016.02.002>
- Gagné, M., Forest, J., Vansteenkiste, M., Crevier-Braud, L., Van den Broeck, A., Aspel, A. K., ... & Westbye, C. (2015). The Multidimensional Work Motivation Scale: Validation evidence in seven languages and nine countries. *European Journal of work and*

- organizational psychology*, 24(2), 178-196.
<https://doi.org/10.1080/1359432X.2013.877892>
- Ganal, N. N., & Guiab, M. R. (2014). Problems and difficulties encountered by students toward mastering learning competencies in mathematics. *Researchers World*, 5(4), 25. E-ISSN2229-4686-ISSN2231-4172
- García-Hernández, A., & González-Ramírez, T. (2021, July). Technology as gamification means in mathematics learning. In *7th International Conference on Higher Education Advances (HEAd'21)* (pp. 581-587). Editorial Universitat Politècnica de València. <https://doi.org/10.4995/head21.2021.13165>
- Gil-Doménech, D., & Berbegal-Mirabent, J. (2019). Stimulating students' engagement in mathematics courses in non-STEM academic programmes: A game-based learning. *Innovations in Education and Teaching International*, 56(1), 57-65.
<https://doi.org/10.1080/14703297.2017.1330159>
- Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing theory and Practice*, 19(2), 139-152. <https://doi.org/10.2753/MTP1069-6679190202>
- Halim, R. A., & Ahmad, H. (2016). Distributed leadership, contextual factor and teachers' self-efficacy in Malaysia. *Educational Leader (Pemimpin Pendidikan)*, 4, 31-38.
- Hallifax, S., Serna, A., Marty, J. C., & Lavoué, É. (2019). Adaptive gamification in education: A literature review of current trends and developments. In *Transforming Learning with Meaningful Technologies: 14th European Conference on Technology Enhanced Learning, EC-TEL 2019, Delft, The Netherlands, September 16–19, 2019, Proceedings 14* (pp. 294-307). Springer International Publishing. https://doi.org/10.1007/978-3-030-29736-7_22
- Hamari, J., & Koivisto, J. (2015). Why do people use gamification services?. *International journal of information management*, 35(4), 419-431. <https://doi.org/10.1016/j.ijinfomgt.2015.04.006>
- Harper, S. R. (2009). *Student engagement in higher education* (p. 1). S. J. Quaye (Ed.). New York: Routledge.
- Hassan, M. A., Habiba, U., Majeed, F., & Shoaib, M. (2021). Adaptive gamification in e-learning based on students' learning styles. *Interactive Learning Environments*, 29(4), 545-565.
<https://doi.org/10.1080/10494820.2019.1588745>
- Hiebert, J. (2007). THE EFFECTS OF CLASSROOM MATHEMATICS TEACHING. *Second handbook of research on mathematics teaching and learning: A project of the national council of teachers of mathematics*, 1, 371.

- Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of educational psychology, 105*(3), 774. <https://doi.org/10.1037/a0032198>
- Huang, L., Doorman, M., & van Joolingen, W. (2021). Inquiry-based learning practices in lower-secondary mathematics education reported by students from China and the Netherlands. *International Journal of Science and Mathematics Education, 19*(7), 1505-1521. <https://doi.org/10.1007/s10763-020-10122-5>
- Hursen, C., & Bas, C. (2019). Use of gamification applications in science education. *International Journal of Emerging Technologies in Learning (Online), 14*(1), 4. <https://doi.org/10.3991/ijet.v14i01.8894>
- Ifenthaler, D., Eseryel, D., & Ge, X. (2012). Assessment for game-based learning. In *Assessment in game-based learning: Foundations, innovations, and perspectives* (pp. 1-8). New York, NY: Springer New York. https://doi.org/10.1007/978-1-4614-3546-4_1
- Kapp, K. M. (2012). *The gamification of learning and instruction: game-based methods and strategies for training and education*. John Wiley & Sons.
- Karakas, F., & Manisaligil, A. (2012). Reorienting self-directed learning for the creative digital era. *European Journal of Training and Development, 36*(7), 712-731. <https://doi.org/10.1108/03090591211255557>
- Karamete, A. (2024). A content analysis of graduate dissertation using the flipped learning method. *Journal of Educational Technology and Online Learning, 7*(2), 208-242. <https://doi.org/10.31681/jetol.1408925>
- Kirillov, A. V., Vinichenko, M. V., Melnichuk, A. V., Melnichuk, Y. A., & Vinogradova, M. V. (2016). Improvement in the learning environment through gamification of the educational process. *International Electronic Journal of Mathematics Education, 11*(7), 2071-2085. Retrieved from <https://www.iejme.com/article/improvement-in-the-learning-environment-through-gamification-of-the-educational-proces>
- Kline, R. B. (2023). *Principles and practice of structural equation modeling*. Guilford publications.
- Kpodoe, I. A., Vanderpuye, I., Ntim, E. K., & Dadzie, J. (2023). Enhancing teachers' understanding and support for students with emotional and behavioral disorders (EBD) in Ghanaian second cycle educational institutions. *Journal of Education and Practice, 14*(28), 30-42. <https://doi.org/10.7176/JEP/14-28-04>

- Kuh, G. D. (2009). What student affairs professionals need to know about student engagement. *Journal of college student development*, 50(6), 683-706. <https://doi.org/10.1353/csd.0.0099>
- Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & gaming*, 45(6), 752-768. <https://doi.org/10.1177/1046878114563660>
- Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother?. *Academic exchange quarterly*, 15(2), 146. Retrieved from https://www.academia.edu/570970/Gamification_in_Education_What_How_Why_Bothe
- Lera, M. J., Leon-Perez, J. M., & Ruiz-Zorrilla, P. (2023). Effective educational practices and students' well-being: the mediating role of students' self-efficacy. *Current Psychology*, 42(26), 22137-22147. <https://doi.org/10.1007/s12144-022-03266-w>
- Liu, C. R., Wang, Y. C., Huang, W. S., & Tang, W. C. (2019). Festival gamification: Conceptualization and scale development. *Tourism Management*, 74, 370-381. <https://doi.org/10.1016/j.tourman.2019.04.005>
- Liu, Y., Bellibaş, M. Ş., & Gümüş, S. (2021). The effect of instructional leadership and distributed leadership on teacher self-efficacy and job satisfaction: Mediating roles of supportive school culture and teacher collaboration. *Educational Management Administration & Leadership*, 49(3), 430-453. <https://doi.org/10.1177/1741143220910438>
- López-Belmonte, J., Parra-González, M. E., Segura-Robles, A., & Pozo-Sánchez, S. (2020). Scientific mapping of gamification in web of science. *European Journal of Investigation in Health, Psychology and Education*, 10(3), 832-847. <https://doi.org/10.3390/ejihpe10030060>
- Manzano-León, A., Camacho-Lazarraga, P., Guerrero, M. A., Guerrero-Puerta, L., Aguilar-Parra, J. M., Trigueros, R., & Alias, A. (2021). Between level up and game over: A systematic literature review of gamification in education. *Sustainability*, 13(4), 2247. <https://doi.org/10.3390/su13042247>
- Marsh, H. W., Hau, K. T., Balla, J. R., & Grayson, D. (1998). Is more ever too much? The number of indicators per factor in confirmatory factor analysis. *Multivariate behavioral research*, 33(2), 181-220. https://doi.org/10.1207/s15327906mbr3302_1
- Martin, J., & Torres, A. (2016). What is student engagement and why is it important. Retrieved May, 4, 2018. <https://nais-xperience->

dev.nais.org/getmedia/61211bd0-f125-4af6-aff0-8be4dc7e691d/2016-HSSSE-Chapter-1.pdf

- Mora, A., Riera, D., González, C., & Arnedo-Moreno, J. (2017). Gamification: a systematic review of design frameworks. *Journal of Computing in Higher Education*, 29, 516-548. <https://doi.org/10.1007/s12528-017-9150-4>
- Mullis, I. V., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020, December). *TIMSS 2019 international results in mathematics and science*. <https://www.skolporten.se/app/uploads/2020/12/timss-2019-highlights-1.pdf>
- Noorbehbahani, F., Salehi, F., & Jafar Zadeh, R. (2019). A systematic mapping study on gamification applied to e-marketing. *Journal of Research in Interactive Marketing*, 13(3), 392-410. <https://doi.org/10.1108/JRIM-08-2018-0103>
- OECD, P. (2019). The results (Volume III): What School Life Means for Students' Lives; PISA.
- Ofosu-Ampong, K., Boateng, R., Anning-Dorson, T., & Kolog, E. A. (2020). Are we ready for Gamification? An exploratory analysis in a developing country. *Education and Information technologies*, 25(3), 1723-1742. <https://doi.org/10.1007/s10639-019-10057-7>
- Oh, S. (2011). Preservice teachers' sense of efficacy and its sources. *Psychology*, 2(3), 235-240. <https://doi.org/10.4236/psych.2011.23037>
- Opoku-Asare, K. (2022). *Gamification as a pedagogical tool to promote environmental sustainability in a university of technology* (Doctoral dissertation, Cape Peninsula University of Technology).
- Papadakis, S. (2020). Evaluating a game-development approach to teach introductory programming concepts in secondary education. *International Journal of Technology Enhanced Learning*, 12(2), 127-145. <https://doi.org/10.1504/IJTEL.2020.106282>
- Papadakis, S., Trampas, A. M., Barianos, A. K., Kalogiannakis, M., & Vidakis, N. (2020, May). Evaluating the Learning Process: The "ThimelEdu" Educational Game Case Study. In *CSEDU (2)* (pp. 290-298).
- Radovic, D., Black, L., Salas, C. E., & Williams, J. (2017). Being a girl mathematician: Diversity of positive mathematical identities in a secondary classroom. *Journal for Research in Mathematics Education*, 48(4), 434-464. <https://doi.org/10.5951/jresmetheduc.48.4.0434>

- Rajani, N. B., Mastellos, N., & Filippidis, F. T. (2021). Impact of gamification on the self-efficacy and motivation to quit of smokers: observational study of two gamified smoking cessation mobile apps. *JMIR serious games*, 9(2), e27290. <https://doi.org/10.2196/27290>
- Reynolds, K. M., Roberts, L. M., & Hauck, J. (2017). Exploring motivation: integrating the ARCS model with instruction. *Reference Services Review*, 45(2), 149-165. <https://doi.org/10.1108/RSR-10-2016-0057>
- Rozhenko, O. D., Darzhaniya, A. D., Bondar, V. V., & Mirzoian, M. V. (2021). Gamification of education as an addition to traditional educational technologies at the university. In *CEUR workshop proceedings* (Vol. 2914, pp. 457-464). Retrieved from <http://ceur-ws.org/Vol-2914/paper46.pdf>.
- Ruhi, U. (2016). Level up your strategy: Toward a descriptive framework for meaningful enterprise gamification. *arXiv preprint arXiv:1605.09678*. <https://doi.org/10.22215/timre-view/918>
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, 55(1), 68. <https://doi.org/10.1037/0003-066X.55.1.68>
- Saleem, A. N., Noori, N. M., & Ozdamli, F. (2022). Gamification applications in E-learning: A literature review. *Technology, Knowledge and Learning*, 27(1), 139-159. <https://doi.org/10.1007/s10758-020-09487-x>
- Sarstedt, M., Ringle, C. M., & Hair, J. F. (2021). Partial least squares structural equation modeling. In *Handbook of market research* (pp. 587-632). Cham: Springer International Publishing. https://link.springer.com/content/pdf/10.1007/978-3-319-57413-4_15.pdf
- Scager, K., Akkerman, S. F., Pilot, A., & Wubbels, T. (2017). Teacher dilemmas in challenging students in higher education. *Teaching in Higher Education*, 22(3), 318-335. <https://doi.org/10.1080/13562517.2016.1248392>
- Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: A cross-national study. *Educational and psychological measurement*, 66(4), 701-716. <https://doi.org/10.1177/0013164405282471>
- Sicuan, S. R. (2025). Mathematical Modeling of Student Performance in Mathematics: Exploring the Impact of Attendance, Study Habits, and Teaching Methods. *IJECA (International Journal of Education*

- and Curriculum Application*), 8(1), 91-102.
<https://doi.org/10.31764/ijeca.v8i1.28930>
- Sola, D., Couturier, J., & Voyer, B. (2015). Unlocking patient activation in chronic disease care. *British Journal of Healthcare Management*, 21(5), 220-225. <https://doi.org/10.12968/bjhc.2015.21.5.220>
- Speier, C., & Frese, M. (2014). Generalized self-efficacy as a mediator and moderator between control and complexity at work and personal initiative: A longitudinal field study in East Germany. In *Organizational Citizenship Behavior and Contextual Performance* (pp. 171-192). Psychology Press. https://doi.org/10.1207/s15327043hup1002_7
- Stronge, J. H. (2018). *Qualities of effective teachers*. AscD.
- Surman, S. H., Dadzie, J., & Ezugwu, I. J. (2024). Exploring The Interplay of Multifaceted Factors: A Comprehensive Analysis of Risk Perception, Anxiety, and Age-Related Dynamics in The Post-Covid-19 Era. *Edukasiana: Jurnal Inovasi Pendidikan*, 3(3), 381-395. <https://doi.org/10.56916/ejip.v3i3.781>
- Surman, S. H., Ezugwu, I. J., Dadzie, J., & Addison, E. (2024). Examining the predictive capacity of school-based assessment on students' mathematics performance in large-scale examinations. *Asian Journal of Education and Social Studies*, 50(6), 348-369. <https://doi.org/10.9734/ajess/2024/v50i61419>
- Swacha, J. (2021). State of research on gamification in education: A bibliometric survey. *Education Sciences*, 11(2), 69. <https://doi.org/10.3390/educsci11020069>
- Thien, L. M., & Chan, S. Y. (2022). One-size-fits-all? A cross-validation study of distributed leadership and teacher academic optimism. *Educational Management Administration & Leadership*, 50(1), 43-63. <https://doi.org/10.1177/1741143220926506>
- Thurston, T. N. (2018). Design case: Implementing gamification with ARCS to engage digital natives. *Journal on Empowering Teaching Excellence*, 2(1), 5. <https://doi.org/https://doi.org/10.26077/vsk5-5613>
- Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of educational research*, 45(1), 89-125. <https://doi.org/10.3102/00346543045001089>
- Tran, L. T., & Nguyen, T. S. (2021). Motivation and Mathematics Achievement: A Vietnamese Case Study. *Journal on Mathematics Education*, 12(3), 449-468. <https://doi.org/10.22342/JME.12.3.14274.449-468>
- Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and teacher education*, 17(7), 783-805. [https://doi.org/10.1016/S0742-051X\(01\)00036-1](https://doi.org/10.1016/S0742-051X(01)00036-1)
- Walker, C. O., & Greene, B. A. (2009). The relations between student motivational beliefs and cognitive engagement in high school. *The*

- Journal of Educational Research*, 102(6), 463-472.
<https://doi.org/10.3200/JOER.102.6.463-472>,
- Wilson, K. N., Ghansah, B., Ananga, P., Oppong, S. O., Essibu, W. K., & Essibu, E. K. (2025). Exploring the efficacy of computer games as a pedagogical tool for teaching and learning programming: A systematic review. *Education and Information Technologies*, 30(4), 4157-4184. <https://doi.org/10.1007/s10639-024-13005-2>
- Wünderlich, N. V., Gustafsson, A., Hamari, J., Parvinen, P., & Haff, A. (2020). The great game of business: Advancing knowledge on gamification in business contexts. *Journal of Business Research*, 106, 273-276. <https://doi.org/10.1016/j.jbusres.2019.10.062>
- Xi, N., & Hamari, J. (2019). Does gamification satisfy needs? A study on the relationship between gamification features and intrinsic need satisfaction. *International Journal of Information Management*, 46, 210-221. <https://doi.org/10.1016/j.ijinfomgt.2018.12.002>
- Yeboah, R., Amponsah, K. D., Commey Mintah, P., Sedofia, J., & Kwarteng Donkor, P. B. (2025). Game-based learning in Ghanaian primary schools: listening to the views of teachers. *Education 3-13*, 53(1), 99-113. <https://doi.org/10.1080/03004279.2023.2171269>
- Yu, J., Huang, C., He, T., Wang, X., & Zhang, L. (2022). Investigating students' emotional self-efficacy profiles and their relations to self-regulation, motivation, and academic performance in online learning contexts: A person-centered approach. *Education and Information Technologies*, 27(8), 11715-11740. <https://doi.org/10.1007/s10639-022-11099-0>
- Yusof, N. A. M., & Shahrill, M. (2021). The effects of nondigital game-based learning on Brunei Darussalam students' mathematical perspectives and achievements. *Southeast Asian Mathematics Education Journal*, 11(1), 25-40.
<https://doi.org/10.46517/seamej.v11i1.113>
- Zahedi, L. R. (2019, June). Implications of gamification in learning environments on computer science students: A comprehensive study. In *126th Annual Conference and Exposition of American Society for Engineering Education*. <https://par.nsf.gov/biblio/10107328>
- Zee, M., & Koomen, H. M. (2016). Teacher self-efficacy and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research*, 86(4), 981-1015.
<https://doi.org/10.3102/0034654315626801>
- Zirawaga, V. S., Olusanya, A. I., & Maduku, T. (2017). Gaming in education: Using games as a support tool to teach history. *Journal of Education and Practice*, 8(15), 55-64.
<https://eric.ed.gov/?id=EJ1143830>

Zourmpakis, A. I., Kalogiannakis, M., & Papadakis, S. (2023). Adaptive gamification in science education: An analysis of the impact of implementation and adapted game elements on students' motivation. *Computers, 12*(7), 143.
<https://doi.org/10.3390/computers12070143>

Bios

JUSTICE DADZIE is a PhD student in educational research at the University of Alabama. He focuses his research on advancing educational assessment practices and examining their impact on student learning outcomes, with a particular emphasis on academic stress and resilience. He investigated how teacher assessment literacy, digital assessment tools, and technology-enhanced learning environments influence student engagement, performance, and well-being. E-mail:

RUTH KEZIAH ANNAN-BREW, PhD, is a Senior Lecturer in the Department of Education and Psychology at the University of Cape Coast, Ghana. She specializes in educational measurement and evaluation, with research interests encompassing teaching methods, mathematics education, and educational assessment. Her work particularly focuses on instrument validation and differential item functioning (DIF) analysis, aiming to ensure fairness and validity in assessments across diverse populations. E-mail:

ELIZABETH DANSO is a master's student in the Department of Communication at North Dakota State University (NDSU), where she also serves as a Graduate Teaching Assistant. She earned her Bachelor of Arts in Communication Studies from the Ghana Institute of Journalism in 2020. Elizabeth's academic interests encompass organizational communication processes, the interplay between communication and technology, and the role of artificial intelligence and big data in shaping public discourse. She is particularly passionate about exploring how digital platforms influence organizational behavior and public relations strategies. E-mail:

NOTE: The authors acknowledge the use of OpenAI's ChatGPT for language refinement. The AI tool provided valuable support in enhancing the clarity and overall quality of this work.