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Gamification for Enhancing Students' Learning Motivation: A Systematic Review

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ABSTRACT

This systematic literature review examines the effectiveness of gamification in educational settings, specifically focusing on its impact on students' learning motivation in science. With growing interest in gamification as a contemporary teaching strategy, this review integrates research across various academic levels. The aim is to determine how gamification influences learning outcomes, with a particular emphasis on motivation. Theoretical frameworks, including Self-Determination Theory, the ARCS model, and Flow Theory, were applied to analyse the data. Following PRISMA guidelines, the review was conducted in four key phases: identification, screening, eligibility, and inclusion. Findings indicate that the impact of gamification on student engagement and learning outcomes is context-dependent, with more pronounced positive effects observed in higher education and specific subjects. However, some studies report minimal or negative effects, highlighting the complexity of implementing gamification. This review underscores the importance of context-aware application and suggests directions for future research to optimise gamification in education, contributing to the ongoing development of innovative educational practices.

Keywords: gamification, learning motivation, educational settings, self-determination theory, ARCS model, flow theory

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1 INTRODUCTION

In the digital age, the fusion of gaming and education has sparked a revolutionary shift in teaching and learning methods. Gamification is not just a popular term but a powerful strategy for revolutionising educational experiences worldwide. Picture a classroom where the thrill of gaming intersects with the depth of academic learning, creating an engaging, interactive, and highly motivating environment for students. Gamification in education uses game elements like points, badges, and leaderboards to make traditional learning activities more engaging and motivating. Mazarakis and Bräuer (2023) state that gamification incorporates gameplay, technology, story, mechanics, and aesthetic elements. Krath et al. (2021) note that the rules and systems governing user interactions vary significantly between digital games. Gamification has significantly boosted student engagement, motivation, and learning outcomes (Deterding et al., 2011; Hamari & Koivisto, 2013). The argument was elaborated more by Rivera and Garden (2021) that engagement in learning and positive behaviours are observed in the learning process, and gamification aims to boost motivation and critical thinking and facilitate active learning. Integrating digital engagement with educational content through gamification is not merely enhancing learning but fundamentally transforming it into a dynamic, vibrant, and enjoyable process for students across all age groups.

Gamification in education is operationally defined by integrating game-based mechanics and dynamics to create engaging and immersive learning environments. According to a study by Hamari et al. (2014), gamification in educational settings significantly improves student engagement and motivation, leading to enhanced learning outcomes. Enhanced learning outcomes are achieved by leveraging the intrinsic and extrinsic motivational factors inherent in game design, such as the desire for achievement, competition, and recognition (Hamari et al., 2014). Several studies evaluated gamification in learning, incorporating game features into non-game environments, such as educational settings or classrooms (Deterding et al., 2011). Gamification in education was conducted to assess its impact on various aspects, including learning motivation, engagement, achievement, and many other areas. Educators can fully leverage gamification techniques to enhance students' academic outcomes, motivation, and immersion in learning (Kim et al., 2020).

Furthermore, the application of gamification in education is linked to improved academic performance. By creating a learning environment that mimics the engaging aspects of games, students are more likely to participate actively and invest effort in their learning process. A study by Dicheva et al. (2015) highlights the potential of gamification to enhance learning experiences and outcomes, particularly in digital learning environments where student engagement towards the lessons can be challenging to maintain (Dicheva et al., 2015).

This systematic literature review aims to critically examine the impact of gamification on learning outcomes, focusing on students' learning motivation at different levels of science education. The concept of gamification goes beyond the mere integration of games into the classroom; it encompasses game mechanics and dynamics like points, badges, leaderboards, and challenges to create an engaging and motivating learning environment (Sholahudin & Yenti, 2022). The underlying premise is that the elements that make games engaging can be used to enhance learning experiences, making them more interactive and rewarding. This review is prompted by the growing

body of literature from previous studies suggesting gamification can positively impact learning. However, the extent and nature of this impact are subjects of ongoing research and debate. This systematic literature review aims to synthesise existing research findings from diverse educational settings, ranging from primary to higher education within the context of science learning, to understand how gamification influences learning outcomes comprehensively.

The objectives of this review are twofold: first, to evaluate the effectiveness of gamification in improving student learning outcomes, particularly focusing on students' learning motivation, and second, to explore how the impact of gamification varies across different educational contexts and subject areas. The systematic literature review examines various gamification tools and techniques and the theoretical frameworks underpinning their use, such as Self-Determination Theory (SDT), the Attention, Relevance, Confidence, and Satisfaction (ARCS) model, and Flow Theory. In the context of rapid digital transformation in education, this systematic literature review explores the effectiveness of gamification as a contemporary teaching strategy. Specifically, it investigates the impact of gamification on students' learning motivation in science, a subject area that has seen increased interest in innovative pedagogical approaches. Aligning with these developments, the study aimed to contribute to ongoing discussions on enhancing student engagement through digital tools. By collating and analysing data from a range of sources, this systematic literature review contributes to a better understanding of the role of gamification in education, highlighting its benefits and limitations. It provides insights into best practices for implementing gamification strategies in educational settings and suggests directions for future research.

Gamification in education garnered significant attention as an innovative approach to enhance learning experiences. The review synthesises findings from various studies to understand how gamification is effectively integrated into educational settings to improve student's learning motivation. Gamification is applying game elements in non-game contexts using game design principles to make educational processes more interactive and enjoyable (Chapman & Rich, 2018; Dugnol-Menéndez et al., 2021). Using game mechanics like points, badges, and leaderboards is integral to this approach, aiming to foster a more dynamic learning environment (Donnermann et al., 2021). In health sciences, gamification techniques like educational escape rooms enhance learning by improving student motivation and developing professional skills (Dugnol-Menéndez et al., 2021). Web-based learning incorporating gamification transforms courses into interactive experiences, motivating learners and making learning fun (Aljraiwi, 2019). Gamification improves student learning motivation and other aspects within an educational context, such as performance and other learning skills. Kalogiannakis et al. (2021) and Li and Chu (2021) reported that gamification across various platforms contributes to enhanced achievement, creativity development, improved thinking and collaboration, and better knowledge retention. Despite the increasing trend of gamification usage across various scientific disciplines and its significant benefits, there is no notable potential in enhancing science learning (Alahmari et al., 2023). A more detailed and extensive study is needed to explore science learning and motivation contexts.

The integration of gamification into educational contexts represents a paradigm shift in pedagogical strategies, intertwining the allure of gaming with the rigour of academic learning. The systematic literature review delves into the burgeoning field of gamification in education, underpinned by established theories of motivation in learning. The review synthesises critical

research findings, exploring how gamification, as a pedagogical tool, leverages motivational theories to enhance learning outcomes. At the heart of gamification in education lies the interplay between intrinsic and extrinsic motivational factors, as conceptualised by Ryan and Deci (2002) in their Self-Determination Theory (SDT). SDT posits that intrinsic motivation, driven by an inherent interest or enjoyment in the task itself, and extrinsic motivation, influenced by external rewards, are critical in fostering engagement and learning (Ryan & Deci, 2000). Werbach and Hunter (2012) propose a framework for understanding gamification's impact on motivation at various levels, integrating components like dynamics, mechanics, and elements in which this approach aligns with behaviourist strategies and Self-Determination Theory, emphasising the role of intrinsic and extrinsic motivation (Azzouz Boudadi & Gutiérrez-Colón, 2020).

It is essential to distinguish between gamification and Game-Based Learning (GBL). While GBL uses actual games for educational goals, gamification narrows to game design elements. This distinction highlights how gamification integrates game elements into the learning process rather than using full-fledged games (Azzouz Boudadi & Gutiérrez-Colón, 2020). In teacher training, gamification was identified as a method to increase motivation and engagement in learning. It transforms traditional learning activities into engaging, game-like experiences (Gómez-Carrasco et al., 2019). Gamification in education presents a promising avenue for enhancing learning experiences. Integrating game elements into educational settings aims to increase student motivation and engagement, thereby improving learning outcomes. Future research should continue to explore the effectiveness and applicability of gamification strategies in diverse educational contexts; thus, the variability is seen in the differing impacts observed in primary, secondary, and higher education, as well as across different subject areas like science and engineering. One significant gap in the existing literature is the inconsistent effectiveness of gamification across different educational settings. This study comprehensively analyses how gamification's impact on student motivation varies across primary, secondary, and higher education, with a particular focus on science subjects. By highlighting these contextual dependencies, the study aims to clarify the conditions under which gamification is most effective.

Previous studies have shown mixed results regarding whether gamification primarily enhances intrinsic or extrinsic motivation. This study addresses this gap by using theoretical frameworks such as Self-Determination Theory (SDT) and the ARCS Model to differentiate the impacts of gamification on these types of motivation. While most findings indicate positive outcomes, the study reveals that gamification contributes more positively to higher education than other educational levels. Although gamification can significantly enhance extrinsic motivation through rewards and competition, its impact on intrinsic motivation is more nuanced and varies depending on the context. Another gap in the literature is the need for more research on gamification's long-term effects and scalability across different educational contexts and the sustainability and adaptability of gamification strategies in various cultural and educational settings. Addressing these gaps is crucial for understanding how gamification can be effectively implemented on a larger scale and sustained over time.

The practical challenges of implementing gamification in classrooms, such as the need for teacher training and resource allocation, should be addressed in the literature. The study addresses this gap by emphasising the importance of providing teachers with the necessary training and resources to

design and implement gamification strategies effectively. It highlights that successful gamification requires well-designed game elements, supportive educational environments, and adequately trained educators when incorporating gamification in the teaching and learning process. Examining the contextual factors that influence gamification's effectiveness in this study provides valuable insights into how gamification can be tailored to specific educational settings, which helps educators and researchers understand the conditions under which gamification is most likely to succeed. On the other hand, the study offers practical guidance for best practices for implementing gamification in education. Identifying practical game elements and emphasising the need for teacher training provides actionable recommendations for educators looking to enhance student motivation through gamification. Finally, the study identifies areas for future research, such as the long-term impacts of gamification and the scalability of gamification strategies. These recommendations help to guide future studies, ensuring that the research on gamification continues to evolve and address critical questions. In summary, this study addresses significant gaps in the literature on gamification and student motivation, providing valuable insights and advancing our understanding of how gamification can be effectively used in educational settings.

Finding the right research question includes several steps. One practical approach is pre-review mapping to identify subtopics within a proposed research question. This method is essential for locating related research and refining the research question by pinpointing key focus areas (Brereton et al., 2007). As a result, two research questions were adopted for the present study.

1. How does the integration of gamification in different levels of science education influence students' learning motivation?

2. What theories and research methodologies could support the research on applying gamification to students’ learning motivation?

2 METHODOLOGY

This systematic review aims to synthesise previous studies related to gamification in the context of students' motivation in science learning. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and cross-referencing techniques were utilised to ensure a comprehensive collection of relevant studies. Various reporting system guidelines are designed to enhance the quality and transparency of research, including Quality of Reporting of Meta-analyses (QUOROM), Consolidated Standards of Reporting Trials (CONSORT), Strengthening the Reporting of Observational Studies in Epidemiology (STROBE), Meta-analysis of Observational Studies in Epidemiology (MOOSE), Grading of Recommendations Assessment, Development, and Evaluation (GRADE), and Enhancing the Quality and Transparency of Health Research (EQUATOR). PRISMA was selected for this systematic literature review because it greatly enhances the clarity, reliability, and utility of systematic reviews, making them invaluable tools in evidence-based practice. The PRISMA approach involves four phases: identification, screening, eligibility, and inclusion, allowing for a structured and rigorous selection process. Additionally, cross-referencing was employed to identify additional studies cited within the selected articles, broadening the scope of the review.

Previous systematic reviews on gamification in education were meticulously read, and the articles included in the study were systematically assessed to determine their relevance. This assessment involved reading the entire article and evaluating its context to ensure it met the study's criteria, focusing on online gamification rather than Physical games such as board games. Only studies synthesising the impacts of gamification on motivation were considered. During cross-referencing, articles where gamification was employed within science learning were prioritised.

It is important to note that not all articles included in this review met the exclusion and inclusion criteria. This decision aimed to include diverse sources, reflecting the varying quality and type of available research on the topic. Non-peer-reviewed articles were included to provide a more comprehensive understanding of the current state of knowledge, acknowledging both established and emerging perspectives. Only papers with completed research and obtained results were selected. Articles were carefully synthesised based on quality to ensure a thorough review.

The collective value of a comprehensive literature review surpasses the individual contributions of each study by synthesising a range of research to draw solid conclusions on major questions, concepts, and problems. It elucidates the interconnections among existing studies, their implications for theoretical frameworks, and directions for future research (Siddaway et al., 2019). Conducting a literature review requires searching comprehensive and up-to-date literature, which involves searching multiple databases to increase the likelihood of obtaining high-quality papers (Mark & Petticrew, 2006). Systematic reviews follow strict scientific methodologies to minimise systematic errors, primarily by identifying, evaluating, and integrating all relevant studies to address a specific research question (Mark & Petticrew, 2006). This systematic literature review was constructed under the PRISMA criteria. According to Liberati et al. (2009), PRISMA provides comprehensive guidelines for conducting systematic reviews across various types of research.

Gillath & Karantzas, (2019) noted that PRISMA ensures a comprehensive and unbiased synthesis of existing research while enhancing transparency and credibility. Journals were collected through a meticulous search in Scopus, ProQuest, and Google Scholar using a strict search string to ensure alignment with the research questions. Multiple searches were conducted to refine the results, as initial searches produced a vast number of papers. Limiting the search was crucial for identifying high-quality articles for this study. The review process followed PRISMA guidelines, comprising four key phases: identification, screening, eligibility, and data analysis, as illustrated in Figure 1.

<table>
<tr><td>Database</td><td>Scopus</td><td>Google Scholar</td><td>ProQuest</td><td></td></tr>
<tr><td></td><td colspan="3">Used search string</td><td></td></tr>
<tr><td>Identification</td><td>n=64</td><td>n=79</td><td>n=17</td><td>Sorted from 2013-2023
Sorted by publication type

The records screened based on title, abstract, and keywords
Records excluded
1. Scopus (n=37) was excluded due to books, conferences, written in a language other than English, and duplication of paper from another database.
2. Google Scholar (n=63) was excluded due to books, conferences, written in other languages than English, and duplication of paper from another database.
3. ProQuest (n=1) was excluded due to books, conferences, written in other language than English, and duplication of paper from another database.</td></tr>
<tr><td>Screening</td><td colspan="3">n=158
Records screened</td><td></td></tr>
<tr><td></td><td>n=27</td><td>n=16</td><td>n=16</td><td></td></tr>
<tr><td></td><td colspan="3">n=57</td><td></td></tr>
<tr><td>Eligibility</td><td colspan="3">Full text excluded due to failure to focus on the research question and the context of gamification in science learning

(n=41)</td><td>Full text assessed</td></tr>
<tr><td>Inclusion</td><td colspan="3">Articles included in the synthesis including (9) from the cross-referencing from other reviews

(n= 25)</td><td></td></tr>
</table>

Figure 1. The flow diagram of the study (Adapted from Gillath and Karantzas (2019) and Liberati et al. (2009)).

2.1 Identification

To address the research questions, the study focuses solely on one main domain: the impact of gamification on learning motivation. To ensure the research context is specifically applied to gamification as the independent variable and motivation as the dependent variable, a search strategy was formulated as proposed by MacFarlane et al. (2022). Understanding the role of search strategies in systematic reviews relies on these essential terms. Search strategies must be reproducible and replicable, meaning they must be transparent and understandable. This ensures that any researcher with the necessary expertise can effectively reuse a specific search strategy (MacFarlane et al., 2022). The search strategy was constructed around two primary aspects: 'search strategies' and 'gamification.' The search was limited to studies published between 2013 and 2024 to ensure the inclusion of relevant research. A general database search was conducted in Scopus, Google Scholar, and ProQuest, focusing on key terms such as motivation, gamification, and learning motivation. The search string used in these databases is detailed in Table 1.

Table 1. Database search string on a motivational domain.

Database	Search string
Scopus	Keywords, title, and abstract search: Gamification OR Game-based AND learning AND on AND motivation AND secondary education AND primary education AND higher education. The journals which do not use the English language are removed
Google Scholar	Keywords, title, and abstract search; Gamification OR Game-based AND learning AND on AND motivation AND secondary education AND primary education AND higher education (advance search applied on exact phrases gamification learning in science)
ProQuest	Keywords, title, and abstract Advance search; Online AND Gamification OR Game-based OR Web-Based AND learning AND on AND motivation AND secondary education AND primary education AND higher education AND In Science NOT Reviews in anywhere; AND Science AND Gamification AND Motivation in abstract: source type limited to scholarly journal; document type limited to article; language limited to English.

2.2 Screening

After conducting database searches and reviewing systematic reviews, additional relevant studies were identified by analysing the citations in the documents discovered. The papers included in the review are limited to those published between 2013 and 2024. The review was restricted to publications in English, and all available publications were examined. These methods allowed for the narrowing down papers to those most relevant for addressing the research questions, facilitating the construction of a detailed systematic literature review. Duplicates were eliminated, and articles were organised according to theme and motivation. A meticulous review process was undertaken to select high-quality papers. The context of the papers was carefully assessed, focusing specifically on gamification in science learning.

2.3 Eligibility and Quality Appraisal

In the third phase of the study, 57 articles were meticulously evaluated for eligibility. This crucial stage involved a detailed review of the articles' titles, abstracts, and primary content to ensure they met the inclusion criteria and aligned with the research goals. Following the evidence-based practice guidelines suggested by Downes et al. (2016), a distinguished professor from the university's education faculty conducted an independent external review. This review was essential for reducing potential biases and enhancing the robustness of the article evaluation process, providing an impartial assessment to confirm the alignment of the articles with the research question. The quality assessment process focused on three critical criteria. First, the study's detailed explanation of its methodology, particularly about gamification's impact on students' learning motivation, was scrutinised. Second, the study's theme or area, specifically the integration of gamification in educational settings, was thoroughly examined. Third, the articles were meticulously analysed to assess their relevance to the motivational aspect. Due to the stringent eligibility process, 25 articles that needed to sufficiently align with the study's criteria were discarded. Meanwhile, nine articles were included in the study through cross-referencing from previous reviews or studies. As a result, 25 articles were deemed suitable for in-depth analysis within the framework of this study. These articles are further organised by title, author, and publication year, as shown in Table 2.

Table 2. Description of the study involved in the meta-analysis.

No	Title	Year
1	Improving Biotech Education through Gamified Laboratory Simulations, Bonde et al. (2014)	2014
2	Gamification: Questing to Integrate Content Knowledge, Literacy, and 21st-Century Learning, Kingsley & Grabner-Hagen (2015)	2015
3	Game-Based Learning and Gamification to Promote Engagement and Motivation in Medical Learning Contexts, Pesare et al. (2016)	2016
4	Examining the Effects of Gamification on Different Variables in Science Education, (Karatas, 2017)	2017
5	Gamifying a General Science Class at University: Collaborative and Competitive Work Implications, Sánchez-Martín et al. (2017)	2017
6	Gamification in Biology Teaching: A Sample of Kahoot Application, Yapıcı & Karakoyun (2017)	2017
7	Use of Digital Game Based Learning and Gamification In Secondary School Science: The Effect on Student Engagement, Learning and Gender Difference, Khan et al. (2017)	2017
8	Gamification as a strategy to improve student learning motivation: Preparing the student for the 21st century, Wangi et al. (2018)	2018
9	The Development and Evaluation of a Computer-Simulated Science Inquiry Environment Using Gamified Elements, Tsai (2018)	2018

10	Effectiveness of Use of Online Games Kahoot! Chemical to Improve Student Learning Motivation, Purba et al. (2019)	2019
11	Gamification of Assessment in the Natural Sciences Subject in Primary Education, Sánchez-Rivas et al. (2019)	2019
12	Nonscientific University Students Training in General Science Using an Active-Learning Merged Pedagogy: Gamification in a Flipped Classroom, Zamora-Polo et al. (2019)	2019
13	Overcoming Motivational Barriers to Understanding and Accepting Evolution through Gameful Learning, (Owens, 2019)	2019
14	To Assess a Gamified 5E Flipped Learning Platform's Effectiveness in Promoting Student Learning and Achievement in Physics, Lai & Foon, (2019)	2019
15	Use of Gamification Applications in Science Education, Hursen & Bas (2019)	2019
16	Using Gamification in a Teaching Innovation Project at the University of Alcalá: A New Approach to Experimental Science Practices, Carrillo et al. (2019)	2019
17	Evaluating the Effects of Introducing Three Gamification Elements in STEM Educational Software for Secondary Schools, Andrade et al. (2020)	2020
18	Improving Problem-Solving Skills in Introductory Physics Using Kahoot!, (Asa'D & Gunn, 2018)	2020
19	A Collaborative Escape Room as Gamification Strategy to Increase Learning Motivation and Develop Curricular Skills of Occupational Therapy Students, Dugnol-Menéndez et al. (2021)	2021
20	A Systematic Evaluation of Game Elements Effects on Students' Motivation, Leitão et al. (2022)	2021
21	Capturing Potential Impact of Challenge-based Gamification on Gamified Quizzing in Classroom Management, Anunpattana et al. (2021)	2021
22	Integrating Smartphone-Controlled Paper Airplane Into Gamified Science Inquiry for Junior High School Students, Cheng et al. (2021)	2021
23	Is Sustainable Online Learning Possible with Gamification?-The Effect of Gamified Online Learning on Students Learning, Park & Kim (2021)	2021
24	Using Gamification as an Online Teaching Strategy to Develop Students' 21st Century Skills, Mårell-Olsson (2021)	2021
25	Gamification in Thermal Engineering: Does It Encourage Motivation and Learning, Suárez-López et al. (2023)	2023

2.4 Data Analysis

In this study, thematic analysis was employed to integrate the articles' findings in the review. The method was chosen for its versatility and systematic approach, making it suitable for synthesising information from various studies. The research utilised thematic analysis to integrate the findings from the articles included in the review. The approach was chosen for its flexibility and systematic nature, making it well-suited for assimilating data from various studies. The methodology adopted in this study was informed by (Flemming et al., 2019), emphasising the effectiveness of thematic synthesis for combining data from different research designs. The initial phase of the analysis involved the creation of detailed and specific initial codes. These codes were a foundation for the

researchers to identify and formulate themes, connecting and comparing data across the studies. An inductive coding strategy was employed to ensure these themes were closely linked to and representative of the initial data, as outlined by (Braun & Clarke 2019). The process led to constructing a research matrix that provides an extensive overview of various studies, categorised based on their research methodologies, tools used for gamification, theoretical models, and their findings. These articles encompass research on the application of gamification in science learning across various educational levels, including primary, secondary, and higher education. The findings from these studies present varied outcomes of gamification in terms of motivational aspects. The systematic literature review research matrix of Gamification on Students' Learning Motivation is shown in Table 3, and the chart showing the frequency count of papers by year is shown in Figure 2.

Table 3. Systematic literature review research matrix of gamification on students' learning motivation.

	Author (year of publication)	Research Methodology		Gamification WBG used	Theory	Field of the study	Findings
		Quantitative Sample	Qualitative Sample				
1	Bonde et al. (2014)	297 students		-Labster simulation	Cognitive theories	Biology Secondary education	Gamification increased students' motivation
2	Kingsley & Grabner-Hagen (2015)	47 students		-3D GameLab	Multifaceted, multimodal, and social aspects of New Literacies	Science Primary education	Gamification increased students' motivation
3	Pesare et al. (2016)	61 Medical students		-Simulation of clinical cases -Edugame	-	Biology Higher education	Gamification increased students' motivation
4	Karatas (2017)	11 5th grade students		-Self-developed	SDT	Science Primary education	Gamification had little effect on students' intrinsic motivation but higher on extrinsic motivation
5	Sánchez-Martín et al. (2017)	36 samples		-Moodle	-	Science Higher education	Gamification increased students' motivation
6	Yapıcı & Karakoyun (2017)	15 samples		-Kahoot!	-	Biology Higher education	Gamification increased students' motivation
7	Khan et al. (2017)	72 samples		-Customized GBL	-	Science Secondary education	Gamification is motivating
8	Wangi et al. (2018)	Quasi 48 samples		-LMS	SDT ARCS	Chemistry Higher education	Gamification increased students' motivation

9	Tsai (2018)	58 students		Gamified computer simulated environment	Scientific Inquiry	Science Secondary education	Positive impacts on student motivation
10	Purba et al. (2019)	40 students		-Kahoot!	Theory of motivation to learn	Chemistry Secondary education	Gamification increased students' motivation
11	Sánchez-Rivas et al. (2019)	217 samples Test,survey		-Propriety mobile application	-	Science Primary education	Gamification increased students' motivation
12	Zamora-Polo et al. (2019)	18 students		-Kahoot! -Socrative -Quizzes	-	Science Higher education	Gamification increased students' motivation
13	Owens (2019)	140 students		-Gamified learning courses	SDT	Biology Secondary education	Improved students' motivation
14	Lai & Foon, (2019)	58 students		-Self-developed	-	Physics Secondary education	Gamification motivated students to learn
15	Hursen & Bas (2019)	16 samples Quanti: Quasi-experimental, Quali: interview students and parents		-ClassDojo	-	Science Primary education	Gamification increased student motivation
16	Carrillo et al. (2019)	150 samples (2017/18) 183 samples (2018/19)		-ClassDojo -Kahoot!	-	Science Primary education	Gamification increased students' motivation
17	Andrade et al. (2020)	199 students		-Custom-developed applications	SDT	Physics Secondary education	No significant differences in student motivation
18	(Asa'D & Gunn, 2018)	60 Students		-Kahoot!	-	Physics Secondary education	Gamification increased students' motivation
19	Dugnol-Menéndez et al. (2021)	Experimental 75		-Escape Room	-	Science Higher education	Gamification enhanced motivation

20	Leitão et al. (2022)	98 samples Quasi-experimental		-Mobile application Ocean Library	-	Biology Primary education	Gamification increased students' motivation
21	Anunpattana et al. (2021)	120 samples Quanti: Kahoot! quizzes results, Quali: interview students		-Kahoot!	-	Physics Primary education	Gamification has a positive impact on student's motivation
22	Cheng et al. (2021)	71 Students		Power-Up 3.0 (airplane system)	Flow Theory Science Inquiry	Science Secondary education	Enhanced motivation inferred from a significant improvement in science process skills among high and middle-flow students
23	Park & Kim (2021)	140 samples Pre-post survey		-Science Level Up	-	Science Primary education	Gamification increased student motivation
24	Mårell-Olsson (2021)		26 samples	-Kahoot!	-	Science Secondary education	Gamification is motivating
25	Suárez-López et al. (2023)	Empirical studies on engineering students from 2015-2020		-Kahoot!	-	Engineering Higher education	Gamification increases students' motivation

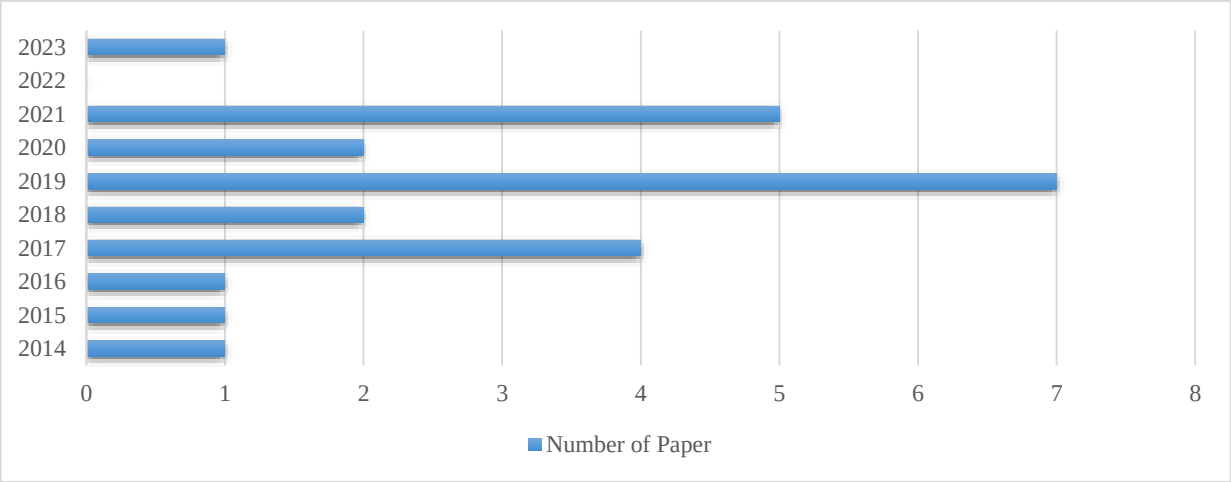

Figure 2. Frequency count by year chart.

3 RESULTS

The systematic literature review encompassed 25 studies from 2013 to 2023 that investigated the impact of gamification on student learning motivation across primary, secondary, and higher educational contexts within the science domain. Analysis of papers over the past decade reveals a peak in publications in 2019, likely due to the increased focus on gamification during the pandemic. The reduced frequency and absence of face-to-face learning prompted more educators to adopt gamification. However, the number of publications declined afterwards, although some studies continued in related fields. The included studies covered various educational levels—higher education, primary education, and secondary education, and explored diverse fields such as science, chemistry, biology, Physics, engineering, and occupational therapy. The analysis examined different gamification strategies, their theoretical underpinnings, and their effectiveness in enhancing student motivation. Sample sizes in these studies varied significantly, ranging from 15 to 297 participants.

Larger sample sizes generally offered more robust statistical power, reducing the margin of error and increasing the generalisability of the findings. Several studies employed theoretical frameworks such as Self-Determination Theory (SDT), the ARCS model, Flow Theory, and various cognitive theories. SDT was frequently used to understand gamification's intrinsic and extrinsic motivational impacts, emphasising the importance of satisfying students' needs for autonomy, competence, and relatedness, as seen in studies by Cengiz and Karataş (2015) and Owens (2019). The ARCS Model was used to design and evaluate gamified interventions, focusing on Attention, Relevance, Confidence, and Satisfaction (Wang et al., 2018). Meanwhile, Flow Theory and cognitive theories explained how gamification enhances engagement and learning by making activities more immersive and rewarding (Cheng et al., 2021). Common gamification strategies included digital tools like Kahoot!, ClassDojo, Moodle, and proprietary mobile applications, with activities such as gamified quizzes, escape rooms, simulation games, and challenge-based learning tasks. The studies were distributed across primary, secondary, and higher education levels, and subjects included science, chemistry, biology, and Physics.

Most studies reported a significant positive impact of gamification on student motivation. For instance, research has shown that gamification enhances engagement, interest, and participation in both primary and secondary education settings (Dugnol-Menéndez et al., 2021; Suárez-López et al., 2023; Park & Kim, 2021). Similarly, Hursen and Bas (2019) and Sánchez-Rivas et al. (2019) found that gamified learning environments increase motivation. However, the effectiveness of gamification is often context-dependent, with higher education settings and specific subjects, such as engineering and physics, demonstrating more pronounced positive effects. Some studies, including those by Cengiz and Karataş (2015), suggest that while gamification may have a limited impact on intrinsic motivation, it significantly boosts extrinsic motivation, particularly among younger students.

Conversely, Andrade et al. (2020) found no significant differences in student motivation, suggesting that the success of gamification depends on the design and implementation of gamified elements. Negative impacts were less common but were noted in contexts where gamification did not align well with students' learning preferences or educational environments. The most commonly used methodologies included experimental designs, quasi-experimental setups, and empirical studies focusing on quantitative and qualitative data to assess the impact of gamification on student motivation. Theoretical frameworks employed in these studies include Self-Determination Theory (SDT), which emphasises the role of autonomy, competence, and relatedness in motivating students. The ARCS model is also frequently used to understand how gamification can enhance the engagement and satisfaction of learning experiences. Flow Theory is occasionally applied to explore the state of complete immersion and engagement that gamification can induce in an educational setting.

4 DISCUSSION

The effectiveness of gamification, as shown in studies like those by Dugnol-Menéndez et al. (2021) and Suárez-López et al. (2023), is linked to its ability to invoke intrinsic and extrinsic motivational factors through interactive and engaging educational experiences. These studies highlight the importance of aligning gamification strategies with educational goals and adapting them to specific learning environments and student needs. The positive results are consistent with SDT, which posits that satisfying students' needs for competence, autonomy, and relatedness can enhance intrinsic motivation. The ARCS model and Flow Theory further explain how gamification can make learning more engaging by making it more interactive and rewarding. Moreover, the variability in the outcomes, as discussed by Park and Kim (2021) and Hursen and Bas (2019), suggests that while gamification can be a powerful motivational tool, its implementation must be carefully tailored to the unique dynamics of each educational setting. The findings call for a balanced approach to gamification, where educators are encouraged to incorporate game elements thoughtfully to ensure that these strategies motivate and enhance learning outcomes. Effective gamification requires a careful design considering the educational context, the target audience, and the specific learning objectives. The studies highlighted the importance of integrating appropriate game elements that resonate with students' interests and curriculum goals.

Further research should explore the long-term impacts of gamification and how it can be scaled and adapted across different educational contexts and cultures, ensuring its effectiveness in

fostering not only motivation but also academic achievement (Dugnol-Menéndez et al., 2021; Hursen & Bas, 2019; Park & Kim, 2021; Suárez-López et al., 2023). The approach would help fully realise the potential of gamification as a transformative tool in education. Research should also explore the impact of specific game elements and mechanics to identify which components are most effective in different educational settings if they apply gamification in the study. Educators should incorporate gamified elements that align students' motivational needs with curricular requirements or learning outcomes. The gamified learning environment should focus not only on boosting motivation but also on improving student performance. Training and resources need to accommodate teachers in a way that helps them design and implement effective gamification strategies in the teaching and learning process. Institutions should foster an environment that supports innovative teaching methods and gamification-friendly facilities to fully utilise gamification in the teaching and learning process to enhance student motivation and engagement.

Experimental designs are applied to establish cause-effect relationships by controlling variables and randomly assigning participants to different conditions. Studies employing experimental designs, such as Dugnol-Menéndez et al. (2021), found significant increases in student motivation when gamification strategies were applied, suggesting a strong causal link between gamification and enhanced learning motivation. Quasi-experimental designs are often used when random assignment is not feasible; these designs attempt to determine causality by comparing groups under different conditions. For instance, Wangi et al. (2018) utilised a quasi-experimental setup to show how integrating SDT and ARCS models within gamification strategies can effectively improve motivation in educational settings. Finally, empirical studies rely primarily on the observation and analysis of data without manipulation. Suárez-López et al. (2023) used empirical methods to gather data over five years, which revealed consistent increases in motivation among engineering students, emphasising gamification's role in sustaining motivation over time. Each of these methodologies contributes differently to the robustness and applicability of the findings, with experimental designs providing strong causal evidence. At the same time, quasi-experimental and empirical studies offer broader insights into gamification's real-world effectiveness. Gamification shows significant potential to enhance student motivation; its effectiveness depends on thoughtful integration and educational adaptation.

Future research should identify the conditions under which gamification is most effective and explore strategies for broader implementation across different educational settings and cultures. The findings of this review also underscore the importance of a nuanced approach to gamification. Gamification can be a powerful tool for enhancing motivation; however, its success largely depends on the thoughtful integration of game elements and the educational context. Future research should focus on the long-term impacts of gamification and its scalability across different educational settings and cultures. Additionally, there is a pressing need for teacher training programs that equip educators with the skills to implement gamification strategies effectively. The approach will ensure that gamification strategies not only engage students but also significantly contribute to students' achievement in learning.

The systematic review presents a comprehensive examination of gamification across various educational settings, with a particular emphasis on science education, allowing for a broad understanding of its application across different levels and contexts. The comprehensive scope

enhances the review's contribution to the literature by providing insights into the generalisability and variability of gamification's effectiveness. Additionally, the review is strengthened by its use of established theoretical frameworks such as Self-Determination Theory (SDT), the ARCS Model, and Flow Theory, which provide a robust foundation for analysing the motivational impacts of gamification. These frameworks enable a deeper exploration of the mechanisms underlying student engagement and learning outcomes, enhancing the scholarly rigour and credibility of the review's findings. Furthermore, the review effectively identifies critical gaps in the existing literature, such as the inconsistent effectiveness of gamification across different settings and the limited research on long-term impacts. The review also offers practical recommendations, emphasising the importance of teacher training and the careful design of game elements to ensure alignment with educational objectives. These insights are precious for educators and policymakers aiming to implement gamification strategies effectively.

Despite its strengths, the review has several notable weaknesses. Including a broad range of studies, including non-peer-reviewed sources, introduces variability in the methodological rigour of the included studies, which can undermine the reliability and validity of the synthesised findings. A more selective approach focusing on high-quality, peer-reviewed research would strengthen the overall conclusions and provide a more robust evidence base. Additionally, the review needs a more thorough focus on the long-term impacts of gamification on student motivation and learning outcomes, as the current literature is limited in longitudinal studies that assess these impacts. The gap restricts the ability to draw comprehensive conclusions about the sustainability of gamification's educational benefits.

Furthermore, while the review acknowledges the context-dependent nature of gamification's effectiveness, it must deeply explore how specific contextual factors, such as cultural differences or subject matter challenges, might influence outcomes. A more detailed analysis in this area would provide a richer, more nuanced understanding of how to adapt gamification strategies effectively. Finally, the review emphasises the positive aspects of gamification, potentially overlooking negative outcomes or challenges, such as the risk of increased competition leading to student stress or distraction from core educational objectives. Addressing these potential drawbacks would offer a more balanced and comprehensive assessment of gamification's role in education. The studies demonstrate that gamification strategies like escape rooms, online quizzes, and mobile applications effectively enhance motivation by integrating game elements into learning environments. These elements cater to intrinsic and extrinsic motivations through immediate feedback, achievement systems, and competitive scenarios.

In conclusion, gamification proves effective in subjects with traditionally lower engagement levels, offering a dynamic learning experience that transforms student attitudes and boosts engagement. However, its impact depends on aligning these strategies with educational objectives and their adaptation to specific student groups. This underscores the importance of careful design and implementation. These findings suggest that while gamification can enhance student motivation, its success depends on contextual factors, including curriculum integration, educational goals, and student demographics. The review also highlights how methodologies contribute differently to the validity and applicability of the findings. Experimental designs provide strong causal evidence, while quasi-experimental and empirical studies offer broader insights into the real-world effectiveness of gamification.

On the other hand, this review provides valuable insights into the ongoing discourse surrounding innovative educational practices. Identifying the challenges and gaps in the effective implementation of gamification in this study provides a foundation for future research and practical applications. The findings underscore the importance of contextual adaptation and teacher preparedness in maximising the potential of gamification as a transformative tool in education. Future studies should continue exploring these variables to optimise gamification strategies for diverse educational settings.

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