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Enhancing Programming Education through Game-Based Learning for Improved Engagement and Learning Outcomes

Fikile Mposula, Kayode Oyetade

Author for correspondence:
Fikile Mposula
fikile@vut.ac.za
Vaal University of Technology, South Africa

Abstract

Background/purpose. Programming education faces persistent challenges, including high attrition rates, low student engagement, and difficulty grasping abstract concepts. Innovative pedagogical strategies are needed to support today's diverse learners better. Game-Based Learning (GBL) has emerged as a promising approach that uses interactive and motivational game elements to enhance learning. This study examines the effectiveness of GBL in programming education, focusing on its potential to improve student engagement, conceptual understanding, and skill acquisition.

Materials/methods. Adopting a descriptive literature review methodology, this study analyzes research published between 2009 and 2025. The review synthesizes evidence on GBL's effectiveness relative to traditional instructional methods, with particular attention to inclusivity, accessibility, curriculum alignment, and recent innovations in AI-driven and immersive GBL platforms.

Results. The findings indicate that GBL significantly enhances student engagement, conceptual understanding, and skill acquisition. At the same time, barriers such as limited infrastructure, teacher preparedness, and inequitable access persist. The review also identifies important gaps, including a lack of longitudinal studies and limited representation of diverse learner populations.

Conclusion. The originality of this study lies in integrating recent technological advancements with a critical focus on inclusivity and sustainable adoption, thereby extending earlier reviews. Practical recommendations are presented for a multi-stakeholder strategy that involves infrastructure development, teacher training, and policy assistance to promote equitable and effective GBL implementation in programming education.

1. Introduction

In an era of rapid technological innovation, traditional programming curricula are increasingly inadequate for engaging today's diverse learners (Bakar, 2021; Kinshuk et al., 2016). Programming, a core discipline in computer science, is intellectually demanding due to its abstract nature and reliance on logical reasoning (Denning & Tedre, 2021). Conventional approaches, often centered on lectures and rote exercises, frequently fail to accommodate varied learning needs, resulting in high attrition rates and limited development of computational thinking skills (Denning & Tedre, 2021; Westwood, 2016).

Educators are exploring innovative pedagogical strategies that leverage digital technologies to create interactive and practical learning environments (Randle & Oyetade, 2025; Sarker et al., 2019). One such approach is Game-Based Learning (GBL), which integrates the motivational and interactive elements of games into education, enabling active learning through exploration, experimentation, and problem-solving within simulated environments (Lampropoulos et al., 2019; Mikrouli et al., 2024). Evidence suggests that GBL enhances engagement, enjoyment, conceptual understanding, and cognitive skill development (Adipat et al., 2021; Rye et al., 2025).

Despite these benefits, research on GBL in programming remains fragmented. Many studies focus narrowly on engagement or short-term outcomes, overlooking inclusivity, curriculum alignment, and long-term impact. Furthermore, AI-enhanced and immersive GBL environments have yet to be fully integrated into programming courses. It poses the question: To what extent does GBL improve engagement, conceptual understanding, and learning outcomes in programming education compared to traditional methods, and how can it be implemented inclusively and sustainably?

This review addresses the question by examining recent studies and case-based insights to explore GBL's effectiveness, contextual adaptability, and alignment with formal curricula. The paper concludes with strategic recommendations for educators and policymakers to promote sustainable, inclusive, and effective adoption of GBL in computer science education.

The paper is structured as follows: Section 2 provides a review and case-based insights into GBL in programming education. Section 3 outlines the research methodology adopted for this study. Section 4 presents the findings on the application and benefits of GBL. Section 5 presents the challenges and barriers to implementing GBL in programming education. Sections 6, 7, and 8 discuss and conclude the paper by summarizing key insights and recommendations and reflecting on the innovative potential of GBL in advancing equitable and practical education.

2. Literature Review

This study adopted a descriptive literature review methodology to identify, analyze, and synthesize empirical studies examining the impact of GBL on student engagement, motivation, and learning outcomes in programming education. While systematic strategies such as database searching, inclusion/exclusion criteria, and quality screening were used to improve transparency and rigour, this study does not claim to be a systematic review. Instead, it presents a comprehensive descriptive synthesis that strikes a balance between breadth of coverage and thematic depth.

2.1. Search Strategy

A focused search was conducted across multiple academic databases to identify relevant papers published between 2009 and 2025. The databases consulted included Google Scholar, IEEE Xplore, and Scopus. Search terms were combined using Boolean operators (AND, OR). They included keywords such as "Game-Based Learning," "Programming skills," "Computer science education," "Educational games," "Digital games," "Student engagement," and "Learning outcomes." For example, one of the search strings employed was: "Game-Based Learning" AND "programming skills"

AND "computer science education." In addition to these database searches, other sources were investigated to widen the scope of the review. Grey literature and the reference lists of key articles were specifically evaluated to identify additional studies that were not indexed in major databases but were relevant to the research focus. This methodology contributed to a more thorough and broad literature base for the review.

2.2. Eligibility Criteria

To maintain focus and relevance, explicit inclusion and exclusion criteria guided the selection of studies:

Inclusion Criteria

Studies were included in the review if they met the following criteria:

- Peer-reviewed journal articles, conference papers
- Articles published between 2009 and 2025
- Articles focused on programming education or computer science
- Articles that included GBL interventions in instructional settings
- Articles that reported empirical findings related to engagement, learning outcomes, or motivation
- Articles written in English

Exclusion Criteria

Studies were excluded based on the following criteria:

- Non-empirical articles (e.g., editorials, opinion pieces)
- Studies unrelated to programming or computer science education
- Publications not using or evaluating GBL
- Research lacking transparent methodology or outcome measures

2.3. Study Selection and Quality Considerations

The review process involved careful screening of titles, abstracts, and full texts to select studies meeting the criteria. While this was not a systematic review, an effort was made to include studies that demonstrated methodological rigor, transparency, and relevance to the research objectives. Quality considerations focused on the clarity of the research design, the validity of the findings, and the appropriateness of the outcome measures.

2.4. Distribution of selected studies

The review covered 42 studies published between 2009 and 2025 that matched the inclusion criteria.

Table 1. Distribution of Included Studies by Year

Period	Number of Studies
2009–2013	1
2014–2018	4
2019–2023	20
2024–2025	17

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Table 1 summarizes their distribution by publication period, showing a notable increase in research output after 2018, coinciding with the rapid expansion of AI-enabled GBL platforms. Overall, the literature indicates a steady growth in attention to GBL in programming education, with recent studies emphasizing AI-driven, immersive, and inclusive approaches that support personalized learning, accessibility, and practical implementation strategies.

3. Literature Review

GBL has emerged as an innovative instructional approach in programming education, offering new avenues for engaging learners, promoting computational thinking, and supporting cognitive development. Unlike gamification, which primarily employs superficial game-like features such as points and badges, GBL integrates educational content directly into the game's narrative and design, promoting active learning through exploration, challenge, and feedback (Christopoulos & Mystakidis, 2023; Su & Zou, 2024). In the context of programming, GBL addresses the inherent complexity of the discipline by providing interactive, visually supported learning environments that simulate real-world problem-solving scenarios (Mikrouli et al., 2024). This chapter presents a thematically organized review of the literature, supported by empirical case studies that illustrate the practical application and impact of GBL strategies. The review centres around three important themes: GBL in programming education, technical advancements, and research gaps.

3.1. GBL in the context of programming education

Programming is often considered one of the most intellectually challenging subjects in the computer science curriculum because of its abstract syntax, logical frameworks, and problem-solving abilities. Traditional lecture-based teaching methods often lead to disengagement, poor conceptual understanding, and high dropout rates in introductory programming courses (Hopper & Brake, 2018). GBL has emerged as a learner-centered alternative that addresses these challenges by integrating game mechanics into programming instruction. This approach enables students to visualize code behavior, receive immediate feedback, and engage with progressively complex tasks, enhancing computational thinking and fostering intrinsic motivation (Adipat et al., 2021; Rugelj & Lapina, 2019).

Research consistently highlights the benefits of GBL in improving engagement, self-regulation, and programming proficiency. For instance, in a systematic review, Gundersen and Lampropoulos (2025) found that digital games promote emotional involvement and self-directed learning. Similarly, Jääskä (2023) emphasizes that GBL provides an accessible entry point into complex programming concepts that are often alienating in traditional settings. Real-world applications of GBL further demonstrate its effectiveness. For example, initially designed for planetary science, the Final Frontier game incorporated logic-based puzzles that supported foundational programming skills in primary schools across Slovakia and Ireland, thereby improving comprehension of abstract concepts (Vu & Feinstein, 2017).

In addition to educational games, commercial titles like Good Sudoku and those developed by Zachtronics cultivate constructionist thinking and abstract reasoning, acting as cognitive scaffolds for algorithmic problem-solving (Miller & Cooper, 2021). At the tertiary level, custom-designed serious games have demonstrated significant potential. For instance, Yang et al. (2024) found that incorporating a role-playing game into an introductory programming course improved motivation, coding accuracy, and student collaboration. Overall, GBL strengthens technical competencies and makes programming education more engaging, inclusive, and impactful.

3.2. Technological Advancements and AI-Driven GBL

The integration of artificial intelligence (AI) and immersive technologies has significantly advanced the capabilities of GBL environments, enabling more personalized and adaptive learning experiences (Wang & Huang, 2025). Intelligent tutoring systems and real-time feedback agents now tailor instruction to individual learner needs, enhancing conceptual understanding and retention. For example, a study by Güner and Er (2025) found that students using an AI-powered programming assistant outperformed peers in exams and demonstrated deeper comprehension. Bekteshi (2025) found that AI-enhanced GBL platforms, particularly those incorporating virtual reality (VR) and adaptive feedback, significantly improve inclusivity and learner engagement by offering real-time formative assessment and personalized interventions.

However, the rapid pace of technological innovation often exceeds pedagogical alignment. This creates a need for frameworks that combine technological capabilities with solid instructional design. Several successful implementations of AI-driven GBL in programming education illustrate its potential. CodeCombat, for instance, teaches Python and JavaScript through interactive battle-style gameplay, requiring learners to write real code to progress (Kroustalli & Xinogalos, 2021). Similarly, Gidget, a puzzle-based debugging game, has proven effective in teaching computational logic to beginners, particularly women and underrepresented groups, by reducing fear of failure and increasing accessibility (Lee et al., 2014). While AI and immersive technologies greatly enhance GBL's instructional power, their full potential lies in thoughtful integration with pedagogical strategies prioritizing inclusivity, personalization, and curricular relevance.

3.3. Research Gap

Despite evidence of GBL's benefits in programming education, several gaps persist. Most studies focus on short-term impacts, leaving long-term learning outcomes and retention largely unexplored (Camilleri, 2023; Ali, 2024). Diverse learner populations remain underrepresented, with limited insights into how GBL supports students across cultural, linguistic, and socioeconomic contexts (Gomez et al., 2022; Rye & Sousa, 2023). Additionally, challenges in curriculum integration and instructional design are evident, with few studies addressing systematic embedding of GBL into syllabi or the pedagogical quality of game design. Finally, the potential of GBL to foster collaboration and peer learning is often overlooked, with emphasis placed primarily on individual gameplay dynamics. Addressing these gaps is essential to ensure GBL's relevance, inclusivity, and sustainability in programming education.

3.4. Synthesis and Contribution

The literature shows that GBL can improve engagement, conceptual understanding, and skill development, with new technologies such as AI and VR magnifying its impact. By combining empirical investigations, technological breakthroughs, and documented gaps, this review offers an extensive viewpoint that goes beyond previous studies. Its unique contribution lies in integrating AI-driven and inclusive ideas with a thorough evaluation of practical implementation barriers. The study consolidates current knowledge and improves the conversation about the long-term, democratic, and pedagogically sound implementation of GBL in programming education.

4. Findings

The literature reviewed reveals a consistent trend: GBL leads to improved learning outcomes, increased motivation, and higher engagement levels than traditional instructional approaches. Through thematic analysis, five core dimensions emerged for comparing GBL and conventional methods presented in Table 1: engagement and motivation, customization and personalization, learning by doing, collaboration and social interaction, and assessment and feedback.

4.1. Comparative Insights: GBL vs Traditional Approaches

Table 1 highlights the pedagogical advantages of GBL over traditional methods in programming education. Unlike lectures' passive, standardized nature, GBL offers a dynamic, interactive, and learner-centered approach that enhances motivation, personalizes instruction, encourages collaboration, and provides timely feedback, key factors for successful learning outcomes. However, its effectiveness depends on the quality of the game design, curricular alignment, and access to technology. Nevertheless, results are not entirely consistent. According to some studies, if gameplay is not closely aligned with learning objectives, the initial novelty of games may fade (Papastergiou, 2009). Additionally, learner characteristics such as prior gaming experience, gender, and learning preferences moderate GBL's effectiveness, indicating that it should complement rather than replace diverse instructional strategies.

Table 1. Comparison of GBL Versus Traditional Learning

Dimension	Game-Based Learning (GBL)	Traditional Learning
Engagement & Motivation	High, due to interactive and goal-oriented design	Often low; reliant on passive instruction
Customization	Adaptive to learner skill levels	Standardized; lacks differentiation
Learning by Doing	Emphasizes practice and experimentation	Primarily focuses on theoretical knowledge
Collaboration	Promotes teamwork and peer learning	Mainly individual tasks
Feedback	Immediate and embedded within gameplay	Delayed and periodic

Additionally, Figure 1 visually shows that GBL significantly outperforms traditional learning across all dimensions (engagement, customization, learning by doing, collaboration, and feedback), underscoring its greater impact on learner experience and outcomes.

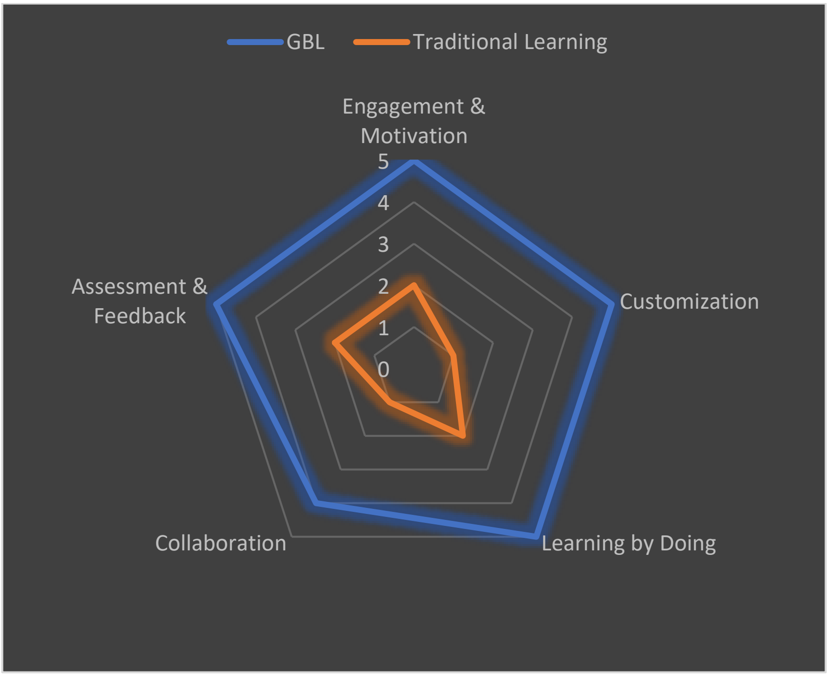

Figure 1. Chart Comparison of GBL Vs Traditional Learning Approaches

Engagement and Motivation: Game-Based Learning environments consistently yield higher levels of student engagement and intrinsic motivation. A study by Hartt et al. (2020) reported greater performance improvement among students using game-based modules compared to those taught through the conventional method. Interactive goals, challenges, and feedback loops contribute to sustained attention and learner involvement. In contrast, lecture-centric approaches are often

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perceived as monotonous, contributing to decreased participation and higher dropout rates in programming courses (Adipat et al., 2021).

Customization and Personalization: A notable strength of GBL is its ability to personalize learning experiences. Many platforms incorporate adaptive mechanisms that adjust content and difficulty in real time based on learner performance (Greipl et al., 2020). AI-enhanced tools, such as programming assistants, exemplify this by tailoring instructional support to individual needs. This personalization ensures learners advance comfortably, reducing cognitive overload (Romero et al., 2024). Traditional classroom models, however, typically follow a uniform curriculum that does not accommodate varying ability levels, often resulting in disengagement or insufficient challenge (Greipl et al., 2020).

Learning by Doing: GBL emphasizes experiential learning by encouraging active experimentation and iterative problem-solving, key elements in mastering programming. Learners can apply theoretical concepts in dynamic, real-world contexts, promoting more profound understanding and retention (Miller & Cooper, 2021; Rye et al., 2025). This is in contrast to traditional pedagogies, which frequently place greater emphasis on theoretical learning and memorization while offering few opportunities for practical experience (Chen et al., 2022).

Collaboration and Social Interaction: Several studies highlight GBL's potential to promote collaborative learning. In multiplayer and team-based environments, learners co-construct knowledge, receive peer feedback, and engage in collective problem-solving (Hughes-Roberts et al., 2023; Zaphiris & Ioannou, 2015). In addition, Vu and Feinstein (2017) found that students in GBL-enhanced STEM classrooms demonstrated improved teamwork, communication, and class participation. In contrast, conventional approaches emphasize individual tasks and assessments, with minimal support for collaborative learning structures (Gomez et al., 2023).

Assessment and Feedback: One of GBL's key advantages is the provision of immediate and formative feedback. Learners receive in-game responses to their actions, enabling real-time adjustments and iterative learning —an especially valuable feature in programming, where timely correction of errors is essential (Jääskä, 2023; Sharma & Giannakos, 2025). Traditional educational methods, on the other hand, often rely on periodic assessments with delayed feedback, reducing opportunities for responsive learning and adaptation (Munna et al., 2024).

4.2. Examples of GBL Tools

Several well-established GBL tools illustrate the diversity of platforms available for programming and general education:

- Kahoot! An interactive quiz platform widely used for formative assessment and review sessions (Özdemir, 2025; Zhang & Yu, 2021).
- Minecraft: Education Edition – Offers a creative, collaborative environment for teaching programming, math, science, and history through simulated play (Alawajee & Delafield-Butt, 2021).
- Duolingo: A gamified language-learning app that uses levels, points, and rewards to drive user engagement (Freeman et al., 2023; Shortt et al., 2023).
- CodeCombat: A game where players write code to control characters and solve programming challenges interactively (Choi & Choi, 2024).
- Classcraft: A role-playing game that gamifies classroom management by rewarding positive behaviour and encouraging teamwork (Parody et al., 2022).

The above results affirm that GBL offers a powerful alternative to traditional instructional methods in programming education. It facilitates more personalized, engaging, and compelling learning experiences while promoting essential skills such as collaboration and self-directed learning.

However, careful integration into curriculum frameworks and fair access to technology resources are necessary to realize GBL's potential fully.

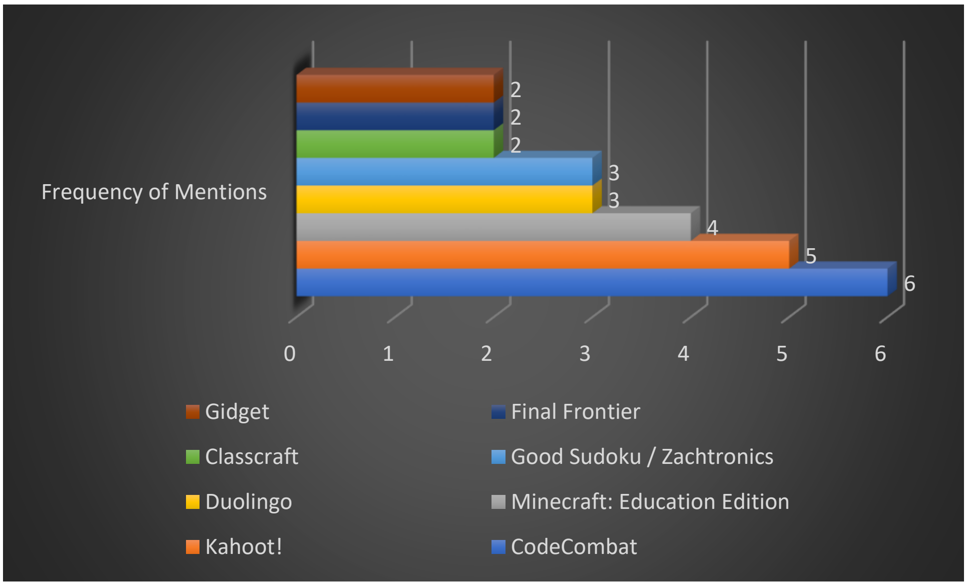

Figure 2. Frequency of GBL Tools Mentions in the Study

In addition to comparing GBL and traditional methods, an analysis of the reviewed studies reveals the most frequently employed GBL tools in programming and related educational contexts. Figure 2 summarizes the distribution, showing that platforms such as CodeCombat, Minecraft, and Kahoot!: Education Edition dominate recent research, while tools like Gidget, Classcraft, and Final Frontier appear less frequently in the reviewed literature. This distribution underscores the central role of widely adopted platforms in shaping discourse on GBL, while also pointing to opportunities to explore less-studied tools further.

5. Challenges and Barriers to Implementing GBL in Programming Education

Despite the numerous pedagogical advantages of GBL, its adoption in programming education remains uneven due to a range of practical, technological, and institutional constraints. This section outlines key barriers identified in the literature, categorized into infrastructural, pedagogical, design-related, and equity-based challenges.

Infrastructural and Financial Constraints: High-quality GBL solutions require investment in game development, licensing, digital infrastructure, and ongoing technical support. Educational institutions, particularly in developing or rural regions, often lack the financial resources to implement or sustain such systems. Additionally, inconsistent access to modern devices and stable internet connectivity can hinder GBL's effectiveness and reinforce educational inequities (Lai & Hu, 2025).

Pedagogical Misalignment and Teacher Readiness: One significant barrier lies in aligning game content with learning outcomes and curricular standards. Many GBL tools, especially commercial games, are not specifically designed to meet educational goals, making meaningful integration difficult. Moreover, educators often lack training or pedagogical orientation to adopt GBL effectively. Without focused professional development and institutional support, GBL may be sidelined as an extracurricular or enrichment activity rather than a fundamental teaching method (Chen et al., 2022; Rye et al., 2025).

Cognitive Overload and Distraction: While engaging, GBL environments can sometimes overwhelm learners if gameplay elements are too complex or insufficiently scaffolded. This "cognitive overload" can detract from learning, particularly when students must simultaneously navigate unfamiliar game mechanics and challenging programming concepts. Effective GBL must balance entertainment and cognitive demands, ensuring that learning objectives remain central and accessible (Faber et al., 2024).

Equity and Accessibility Challenges: Disparities in digital access remain a serious concern. Students from underprivileged backgrounds may lack the hardware, connectivity, or digital literacy needed to participate in GBL activities fully. Furthermore, students with disabilities are frequently excluded due to a lack of accessible game design features such as screen readers, flexible interfaces, and alternative input methods. Inclusive design and universal accessibility must be central to the development of future GBL tools (Lai & Hu, 2025).

Time and Resource Demands on Educators: Implementing GBL requires significant time and effort from educators. This entails learning new platforms, customizing curriculum, managing classroom dynamics, and creating new evaluation procedures. Given existing workloads and time constraints, many educators may find integrating GBL without substantial support impractical. Moreover, the absence of integrated analytics and evaluation tools within many GBL platforms complicates tracking student progress and learning outcomes (Jääskä, 2023).

These multi-layered challenges highlight the systemic considerations required for GBL to evolve from a promising innovation into a widely adopted educational practice. Overcoming these barriers demands a coordinated, strategic approach that includes institutional investment in infrastructure and educator training, as well as the development of curriculum-aligned, accessible GBL tools. Equally important is establishing professional development pathways that equip educators with the necessary skills to implement GBL effectively. Furthermore, supportive policy frameworks must be put in place to promote fair access and ensure the long-term viability of GBL programs. When these prerequisites are realized, GBL will be better positioned to transform programming instruction across a variety of learning environments.

6. Discussion

The reviewed literature demonstrates that GBL offers substantial pedagogical value as an innovative approach in programming education. Across studies, consistent evidence shows that GBL promotes student engagement, motivation, and conceptual understanding while fostering computational thinking and problem-solving abilities. These findings suggest that GBL addresses persistent challenges in programming education, including high attrition rates, low engagement, and difficulty grasping abstract concepts, thereby positioning it as a promising alternative to traditional instruction.

When interpreted in light of prior research, these results align with broader findings in educational technology and constructivist learning theory. For example, Papastergiou (2009) and Hopper and Brake (2018) noted that lecture-based pedagogies often disengage learners, whereas interactive environments encourage participation and persistence. More recent studies by Adipat et al. (2021) and Gundersen and Lampropoulos (2025) reinforce the idea that GBL enhances self-directed learning and collaborative skills, especially when games are closely aligned with instructional objectives. This study verifies these trends and highlights that scaffolding, feedback loops, and adaptive game mechanics, which are increasingly provided by AI-driven platforms, enhance GBL's effectiveness.

At the same time, research reveals difficulties and inconsistencies in implementation. While infrastructure and teacher preparedness have long been acknowledged as concerns, this study demonstrates how these issues remain even in current circumstances (Chen et al., 2022; Rice, 2007). The digital divide remains a central concern, with inequities in access to devices, connectivity, and accessible game design features (Rye et al., 2025). Furthermore, the lack of robust evaluation frameworks limits the ability to measure deeper learning outcomes beyond surface metrics such as participation or completion.

The unique contribution of this review lies in its synthesis of emerging themes that extend beyond earlier studies. Specifically, it examines the role of AI-driven, immersive technologies in enabling adaptive and inclusive GBL environments —an area that has gained traction only in recent years. It also foregrounds inclusivity, accessibility, and curriculum alignment as critical but underexplored dimensions in the discourse on programming education. By integrating these perspectives, the review offers a more holistic and forward-looking understanding of GBL's role and provides a foundation for sustainable adoption across diverse educational contexts.

Finally, while GBL demonstrates clear pedagogical advantages over traditional methods, its transformative potential depends on thoughtful implementation, equitable access, and continuous evaluation. Addressing these conditions will ensure that GBL evolves from an emerging innovation into a sustainable driver of programming education.

7. Recommendations

Based on the findings and discussion, some recommendations are offered to strengthen both research and practice in the field of Game-Based Learning (GBL) in programming education:

For Practice:

- **Curriculum Integration:** Systematically embed GBL into programming curricula to ensure alignment with defined learning outcomes and 21st-century skills.
- **Teacher Training and Support:** Provide professional development to enhance teachers' technical and pedagogical capacity for effective GBL implementation.
- **Infrastructure and Accessibility:** Expand digital infrastructure and adopt universal design principles to ensure equitable access for learners across diverse contexts.
- **Policy and Institutional Support:** Establish supportive policies and long-term investments to promote sustainable adoption of GBL.

For Research:

- **Longitudinal Impact Studies:** Conduct long-term evaluations to assess GBL's sustained effects on programming proficiency, retention, and problem-solving skills.
- **Inclusivity and Diversity:** Explore how GBL can serve underrepresented and resource-limited populations better.
- **Emerging Technologies:** Investigate ethical integration of AI, VR, and AR in GBL to maximize personalization, inclusivity, and engagement.
- **Evaluation Frameworks:** Develop standardized models to measure deeper competencies such as collaboration, creativity, and critical thinking.

By implementing these recommendations, educators, policymakers, and researchers can collectively support the sustainable and inclusive adoption of GBL as a strategy for programming education.

8. Conclusion

This review demonstrates that GBL holds strong potential to transform programming education by enhancing engagement, motivation, and learning outcomes while supporting the development of computational and problem-solving skills. Unlike traditional lecture-based methods, GBL offers interactive, learner-centred experiences that align with constructivist and experiential learning theories. The original contribution of this review lies in consolidating evidence on GBL while incorporating recent developments in AI-driven and immersive technologies, inclusivity, and curriculum alignment. By providing a critical synthesis of current knowledge, this study offers a comprehensive framework for understanding both the opportunities and challenges of implementing GBL in programming education. Finally, the findings emphasize that, if thoughtfully integrated and supported, GBL is not a passing novelty but a viable pathway toward equitable and effective pedagogical programming.

9. Study Limitation

The utilization of secondary literature, much of which focuses on fast outcomes in settings with ample resources at the university level, limits our review. This limits the applicability of the findings to settings with limited resources or that are not universities. In addition, variations in game design, implementation practices, and assessment approaches across studies limit the comparability of results. Future reviews could address these limitations by incorporating longitudinal studies, expanding to more diverse learner populations, and applying standardized evaluation frameworks to ensure methodological consistency.

Declarations

Author Contributions. F.M.: Conceptualization and design, literature search, writing – original draft and final draft. K.E.: Supervision, writing – review & editing. All authors have read and approved the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

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Ethical Approval. Ethical approval is not applicable for this study.

Data Availability Statement. The data that support the findings of this study can be openly accessed from multiple sources, including the websites of several organizations, publicly available reports, and indexed databases of academic journals.

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About the Contributor(s)

Fikile Mposula, Vaal University of Technology, South Africa
Email: fikile@vut.ac.za
ORCID: https://orcid.org/0009-0004-4860-7693

Kayode Oyetade, Vaal University of Technology, South Africa
Email: kayodeo@vut.ac.za
ORCID: https://orcid.org/0000-0003-0516-0639