

Pedagogical Innovation of Game-Based Learning for 21st Century Skills in Vocational Education: A Systematic Literature Review

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ABSTRACT

Vocational education faces the demand to equip learners with 21st century skills to cope with the changing job needs. This study aims to comprehensively explore the pedagogical innovation of Game-Based Learning (GBL) in shaping and enhancing such skills in vocational education. Using the Systematic Literature Review (SLR) method, 35 relevant articles were thematically analyzed from the Scopus database. The results showed an increasing trend in the use of GBL, especially serious games and VR simulations used in various vocational sectors such as engineering and health. GBL designs often integrate development models such as ADDIE and Discovery Learning approaches, utilizing interactive game elements for authentic scenarios. GBL is proven to significantly increase learner motivation and engagement. In addition, GBL is effective in developing 21st century skills such as logical thinking, problem solving, cognitive and affective skills, and contributes to improved academic performance. In conclusion, GBL is an effective pedagogical innovation to prepare vocational education graduates with relevant competencies for future job competition.

Keywords: *21st Century Skills, Game-Based Learning, GBL, Pedagogical Innovation, Vocational Education*



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INTRODUCTION

The digital age and the Fourth Industrial Revolution (4IR), or Industry 4.0 have brought significant changes in the world of work. These changes require individuals to have more adaptive and interdisciplinary skills that fit the needs of the 21st century. Skills such as critical thinking, problem solving, creativity, collaboration, communication, and digital literacy are essential for success in a dynamic and competitive global job market (Rismana & Hernawati, 2025; Thornhill-Miller et al., 2023). In the context of vocational education, educators bear a great responsibility to equip learners with relevant competencies. The aim is to prepare learners to face challenges while being able to take advantage of opportunities in the future. Therefore, the integration of technology and innovative pedagogical approaches is no longer an option, but a necessity (Hamzah et al., 2024).

The development of 21st century skills has become a widely recognized issue. However, educators and vocational education institutions still face various challenges in implementing them into curricula and learning practices. Teacher-centered and less interactive teaching

methods often fail to facilitate the development of complex soft skills, such as collaboration and problem-solving (Tang, 2023). Field data shows that there is a significant gap between the curriculum offered and the real needs of the industry. Many vocational education institutions face limitations in facilities and availability of industry-experienced instructors, so graduates are often unprepared for the demands of the world of work (Singun, 2025; Wibawanto et al., 2021). In addition, the problem of vocational students' learning motivation often arises, characterized by a lack of enthusiasm and a tendency to get bored easily during the learning process (Hidajat et al., 2020).

The skills gap and low motivation to learn in vocational education can be traced back to several key causes. First, the practice-oriented nature of vocational learning requires immersive and authentic learning environments. However, this is often hindered by limited facilities or difficulties in creating complex and risky real-world scenarios (Qin, 2024). Secondly, the lack of engaging pedagogical approaches and personalized learning can lead to learner boredom and indifference. Monotonous learning environments are also less favorable for stimulating creativity and innovative thinking (Georgopoulou et al., 2024). This situation is exacerbated by the rapid pace of technological change, which makes teaching materials obsolete and demands continuous adaptation of the curriculum to maintain its relevance (Chukwuemeka & Garba, 2024).

It is important to conduct in-depth research on pedagogical innovation in vocational education. The urgency of this research lies in two main reasons. First, to ensure the relevance of vocational graduates to the needs of the labor market, so as to contribute to the reduction of unemployment while increasing competitiveness (Odilovna, 2025). Second, to identify and recommend learning strategies that are proven to be effective and engaging. These strategies are expected to address the challenges of learner motivation and engagement, while systematically developing much-needed 21st century skills. Without proven innovation, vocational education risks falling behind and failing to fulfill its strategic role in national economic development (Aseery, 2023).

In response to these issues, Game-Based Learning (GBL) has emerged as one of the most promising pedagogical innovations. GBL involves the use of games or game elements in an educational context to achieve specific learning objectives (Hartt et al., 2020; Gripl et al., 2020). This solution is important because GBL inherently encourages active engagement, fosters intrinsic motivation, and provides a safe learning environment for exploration and experimentation. Through simulations and challenges presented in games, learners can practice skills in realistic scenarios without significant risk, receive instant feedback, and iteratively develop problem-solving and critical thinking skills (Ghoman et al., 2020).

GBL is theoretically rooted in constructivism theory, which believes that learners actively construct their own knowledge through interactive experiences. In addition, GBL also effectively applies the motivational principles discussed in Self-Determination Theory. This theory emphasizes the importance of autonomy, competence and relatedness as key drivers of intrinsic motivation (Lasala Jr, 2024). The various intrinsic elements in the game, such as clear goals, structured rules, adaptive feedback, and challenges tailored to skill levels, effectively fulfill these psychological needs. Therefore, GBL goes beyond mere information transfer, but rather focuses on developing behaviors and skills through immersive and meaningful learning experiences (Gripl et al., 2020).

The advantages of GBL as a pedagogical innovation are manifold. First, GBL significantly increases learner motivation and engagement thanks to the fun and challenging nature of the game (Nadeem et al., 2023). Second, GBL facilitates the simultaneous development of cognitive and non-cognitive skills, including problem solving, creative thinking, decision making, strategic thinking, collaboration (Wang et al., 2023). Third, GBL provides a safe learning environment to experiment and make mistakes, where failure is considered a natural part of the learning process

rather than an obstacle (Gripl et al., 2020). Fourth, GBL allows personalization and flexible customization of learning to suit each individual's learning pace and style (Chiotaki et al., 2023).

Previous studies have examined the effectiveness of GBL at various levels of education, including higher education and vocational education. For example, a study by Yu et al. (2020) showed that the use of educational games can significantly improve academic achievement and learner engagement in certain subjects. Other research also suggests that game-based simulations are effective in practicing procedural and problem-solving skills in various professional fields (Vázquez-Calatayud et al., 2024). However, the specific application of GBL in vocational education with a focus on developing 21st century skills still require more comprehensive synthesis.

In contrast to many previous literature reviews that tend to focus on the effectiveness of GBL in general or limited to specific disciplines, this study will explicitly synthesize findings on GBL as a pedagogical innovation aimed at developing 21st century skills in the context of vocational education. This study aims to provide a more detailed understanding of the types of GBL, effective pedagogical designs, and how GBL directly contributes to enhancing critical skills such as critical thinking, collaboration, and adaptability among vocational learners. Therefore, the uniqueness of this study lies in the conceptualization of GBL as a systematic pedagogical innovation that specifically targets 21st century skills in the unique and dynamic landscape of vocational education.

Based on the background, problem identification, and research gaps described above, this article will conduct a systematic review to deeply explore the pedagogical innovation of game-based learning for 21st century skills in vocational education. Through this systematic review, this study aims to comprehensively explore how Game-Based Learning serves as an effective pedagogical innovation in shaping and enhancing 21st century skills in the vocational education environment.

METHODS

Research Design

This study used a Systematic Literature Review (SLR) approach to comprehensively analyze the scientific literature on Game-Based Learning (GBL) pedagogical innovations in developing 21st century skills at the vocational education level. SLR was chosen because it enables the identification, evaluation, and synthesis of relevant evidence in a systematic, transparent, and replicable manner, thereby minimizing bias and increasing the validity of findings. This study aims to identify recent trends, patterns of findings and research gaps related to the application of GBL to equip vocational learners with essential skills relevant to the demands of today's world of work. A systematic review of selected academic articles was conducted, emphasizing thematic analysis of the design, implementation, and impact of GBL on 21st century skills development.

Participants and Data Sources

The data sources in this study came from 35 scientific articles focusing on Game-Based Learning in vocational education. These articles include publications in scopus-indexed international journals and proceedings. The process of obtaining articles was done through a systematic search using a combination of relevant keywords, such as: "game-based learning", "vocational education", "vocational training", "21st-century skills". Articles were selected from countries with diverse vocational system backgrounds, reflecting the diversity of GBL implementation contexts. The inclusion criteria applied included: (1) articles that addressed vocational education; (2) articles that focused on the use or analysis of Game-Based Learning or educational games; and (3) articles that explicitly examined the development of 21st century skills as a learning outcome or impact of GBL implementation.

Analysis Procedure

Data analysis was conducted systematically with a qualitative thematic approach, following the general stages in SLR. The process began with the identification and collection of articles through a predetermined keyword search. Thereafter, articles were rigorously screened based on title, abstract, and then full content to assess eligibility and relevance to the research topic. Articles that did not meet the inclusion criteria were excluded from the review. After the selection stage, articles that met the criteria were entered into a structured data extraction sheet.

The analysis process was conducted using open coding techniques to identify initial concepts and categories, followed by axial coding to establish relationships between categories. Data that had been extracted and coded were then analyzed through the stages of data reduction, data presentation in the form of a matrix or thematic narrative, and conclusion drawing. Synthesis was conducted to assess emerging patterns, differences in findings, and the unique contribution of each article to the understanding of the impact of GBL pedagogical innovations on the development of 21st century skills. The 21st century skills that were the focus of the analysis included, but were not limited to, critical thinking, problem solving, creativity, innovation, collaboration, communication, and digital literacy. The results of this study were then used to formulate conceptual conclusions, implications, and recommendations.

RESULTS AND DISCUSSION

Results

The results of a systematic review of 35 articles from 2020 to 2025 show that the Game-Based Learning (GBL) approach in vocational education continues to develop significantly, both in terms of pedagogical approaches, vocational sectors touched, and targeted 21st century skills. The variety of approaches used include role-playing games (RPG), virtual reality (VR), gamification, interactive narratives, and escape rooms, with the main goal of encouraging active participation, motivation to learn, and the formation of essential social and professional skills.

Emerging trends show that most GBL studies in vocational education focus on strengthening skills such as collaboration, problem solving, critical thinking, communication, and digital literacy. Reported impacts include increased learning motivation, learner engagement, effective learning of complex concepts, and personalization of learning pathways based on individual interests and needs. Table 1 shows a summary of the main findings from the key articles.

Table 1. Findings of Game-based Learning in Vocational Education (2020-2025)

No	Source	GBL Type/ Approach	Vocational Sector	21 st Century Skills	Key Impacts/Key Findings
1	Zuo et al. (2025)	Theoretical Games	Entrepreneurs hip	Innovation, Strategy	Strategy adaptation, innovation reinforcement
2	Liu & Zheng (2025)	Evolutionary Game	Elderly Care	Collaboration, Risk Management	Subsidies boost school-industry cooperation
3	Fang (2024)	AI Game Simulation	Engineering	R&D, Collaboration	Incentives and supervision improve R&D quality
4	Yu & Abdullah (2025)	Listening Game	English	Motivation, Language Literacy	Improving motivation & listening skills
5	Gutierrez et al. (2025)	Interactive Narrative + AI	Career Guidance	Self-Reflection, Career Interests	Participant responses relevant to academic strengths

No	Source	GBL Type/ Approach	Vocational Sector	21 st Century Skills	Key Impacts/Key Findings
6	Ahmadian et al. (2024)	Digital Game	English	Empathy, Literacy	Gender affects meaning and response to games
7	Widjajanti et al. (2024)	Math RPG	Math	Motivation, Self-Discipline	RPGs are valid and effective in increasing motivation to learn
8	Arianti et al. (2024)	RPG + Discovery	Programming	Logical Thinking	Positive response games, integration of discovery learning model
9	Boel et al. (2023)	VR Games	Safety	Risk Perception	Low-cost VR effective in improving safety understanding
10	Lochbühler et al. (2024)	Game Usage Survey	General	Digital Literacy, Social Balance	Tendency to overuse social media and games
11	Dahalan et al. (2023)	SLR GBL & Gamification	Multisector	Critical, Collaborative	Increasing trend in Asia, dominated by engineering & healthcare
12	Li & Wu (2024)	Game Equilibrium Model	Regional Economy	Cooperation, Strategy	School-industry synergy influenced by fiscal incentives
13	Koivisto et al. (2023)	VR Escape Game	Rehabilitation	Life Skills	Effective for youth self-management training
14	Göbel et al. (2024)	Serious Game	Technician	Problem Solving	Use of SG4BB for cardboard technician training
15	Jiang (2023)	Game Equilibrium	Vocational University	Learning Enthusiasm	Split equilibrium model effective in mobilizing learning motivation
16	Huang (2022)	Mobile Pervasive Game	Field Observation	Reflection, Technology Literacy	Digital experience improves learning performance
17	Wu et al. (2023)	Multi-Player Game	Vocational Governance	Collaboration, Decision- Making	Government strategy determines the direction of vocationalization.
18	Peng et al. (2023)	Land Game	Local Culture	Cultural Literacy	Promotion of local culture through game design & education
19	Amran (2023)	Online Ball Game	Physical Education	Physical Activity, Collaboration	Effective learning media improves student learning outcomes
20	Yang et al. (2022)	Game Addiction Survey	General	Self-Identity, Emotion Regulation	POGU is associated with low self-esteem
21	Jhan et al. (2022)	Digital SCM Game	Supply Chain	Decision Making	GBL uncovers gendered learning pathways
22	Rotter et al. (2022)	Metadata Platform	Multivocational	Critical, Personal Learning	Occupational metadata-based SG matching system
23	Boel et al. (2022)	SAVR - VR Game	Vocational Engineering	Hazard Perception	Positive evaluations for VR as a safety training tool

No	Source	GBL Type/ Approach	Vocational Sector	21 st Century Skills	Key Impacts/Key Findings
24	Lei & Cardoso (2022)	Serious Games	Disability	Inclusion, Collaboration	Stakeholder support for inclusive games increases
25	Mardi et al. (2022)	Monopoly Game	Accounting	Motivation, Discipline	GBL increases learner motivation in basic subjects
26	Azizan et al. (2021)	Automotive GBL	Automotive AC	Cognitive, Affective	Game-based module produces higher results than conventional methods
27	Jing & Mingming (2021)	Online Game	General	Self-learning, Discipline, Autonomy	Online games can support or disrupt learning
28	North et al. (2021)	GBL Platform	Multivocational	Instructional Innovation	Platform helps teachers access & customize GBLs
29	Elmunyah et al. (2021)	Degrad Game	Graphic Design	Visual Creativity	Game aids understanding of color & basic design concepts
30	Dochtsi et al. (2020)	Escape Room Logic Game	Electronics	Problem Solving	Digital logic games help understand logic gates
31	Hesse et al. (2021)	Digital Professions Game	Digital Professions	Career Literacy	Game supports understanding of digital work fields
32	Cárdenas-Moncada et al. (2021)	Kahoot	EFL	Cognitive, Communication	Response-based GBL improves outcomes & motivation
33	Larasati et al. (2020)	Logic Game	Algorithms	Basic Logic	Helps non-IT people understand basic algorithms
34	Ratu et al. (2020)	Conflict Resolution Game	General Vocational	Social-Emotional	GBL helps instill a culture of peace in vocational settings
35	Kotsifakos et al. (2019)	Online Digital Logic Game	Electronics	Logic, System Understanding	Game helps understand logic gates and digital systems

Discussion

Research findings confirm that the integration of GBL in vocational education not only encourages more active and contextualized learning engagement, but also reinforces the hypothesis that experiential approaches and interactivity play a major role in shaping essential 21st century competencies (Dahalan et al., 2023). Various studies show that GBL is able to present complex material in a fun and meaningful way, and facilitate problem-based learning and reflection, as seen in the “Pass Your Limit” study (Widjajanti et al., 2024) and the discovery learning-based RPG game for basic programming (Arianti et al., 2024). In line with this opinion, simulation-based multimedia in vocational education has also proven effective in improving students' skills in practical learning (Wibawanto et al., 2022a).

This discussion also shows coherence with social constructivism theory which states that meaningful learning occurs through active interaction with context and experience (Gutierrez et al., 2025). For example, the use of interactive narratives for real-time assessment of vocational

interests can improve the match between career choices and learners' academic strengths, reinforcing the principle of personalization in education (Gutierrez et al., 2025).

On the other hand, there are some important caveats that point to conceptual and practical challenges. One is the tendency to under-represent metacognitive and self-regulation skills in game design, which is reflected in the lack of critical reflection measurement or training in most studies. In addition, some studies have noted a gender gap in gaming experiences in vocational classrooms, such as in the Adventures with Anxiety study, where perceptions of games differed between male- and female-dominated classes (Ahmadian et al., 2024).

The results of this study enrich the literature and improve the results of previous studies that still focus on cognitive aspects only. GBL now targets not only material comprehension, but also professional identity development and emotion management of vocational learners (Yu & Abdullah, 2025; Koivisto et al., 2023). In addition, the integration of technologies such as VR and AI further expands the potential of GBL in creating immersive and contextualized learning experiences (Boel et al., 2023; Fang, 2024).

The theoretical implications of this study indicate the importance of developing a learning design model that explicitly integrates GBL elements with 21st century skills scaffolding strategies. In terms of application, the results emphasize the urgency of training vocational teachers in designing and integrating game media pedagogically, not just technologically. The effectiveness of multimedia-based learning in vocational education, such as in improving participants' practical skills, can illustrate the pedagogical value of technology-enhanced practical simulations (Wibawanto et al., 2022b).

Future research directions include developing a game-based 21st century skills evaluation framework, long-term effectiveness testing, and exploring the potential of GBL for cross-cultural and inclusive learning, as is being pursued in GBL research for learners with special needs (Lei & Cardoso, 2022).

Overall, it can be concluded that GBL in vocational education shows strong potential as a pedagogical innovation that can bridge the gap between the world of education and the world of work. By paying attention to context, learner diversity, and integration with the curriculum, GBL can be a relevant strategy to produce vocational graduates who are adaptive, collaborative, and ready to face challenges in the 21st century.

CONCLUSION

The research concluded that Game-Based Learning (GBL) in vocational education has proven to be an effective pedagogical approach in supporting the development of 21st century skills, especially in the aspects of motivation, collaboration, critical thinking, and problem solving. The analyzed studies show that GBL not only enriches conventional learning methods, but also brings innovation by integrating interactive technologies such as VR, AI, and narrative games to create a more personalized, contextual, and reflective learning experience. This conclusion supports the hypothesis that GBL has the potential as an innovative solution to address the challenges of relevance of vocational education to the changing needs of the world of work.

Practically, the findings provide new directions for educators, curriculum developers and policy makers to strengthen the vocational learning ecosystem through the integration of pedagogically designed GBL. Investments in teacher training, adaptive platform development, and collaboration with industry are needed to ensure the sustainability and effectiveness of GBL implementation. Further research also needs to be directed towards developing models to evaluate the impact of GBL on cross-disciplinary competency formation, as well as testing its effectiveness in the long term and in more diverse contexts.

CONFLICT OF INTEREST

There is no conflict of interest regarding the publication of this article.

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