GAME-BASED LEARNING IN HIGH SCHOOL BIOLOGY EDUCATION: GLOBAL AND THAILAND PERSPECTIVES

Pakorn Lekvongphiboon
Srakrachomsophonpittaya School, Suphanburi
E-mail: Pakorn@skps.ac.th

Received: 2025-04-30; **Revised:** 2025-05-25; **Accepted:** 2025-06-03

Abstract

This study explores the integration of board games as a game-based learning (GBL) approach in high school biology classes, aiming to enhance student engagement and comprehension of complex scientific concepts. By simulating real-world biological scenarios, such as ecosystems and resource management, educational board games promote critical thinking, collaboration, and systems thinking. This paper synthesizes findings from Thai and international research, examining key aspects of game design, classroom implementation, learning outcomes (knowledge acquisition and 21st-century skills), and associated challenges. Through case studies, the study highlights successful applications of biology board games in classroom settings and evaluates their impact on student interest and learning. Results demonstrate that thoughtfully designed and effectively implemented board games can significantly enhance biology education, providing actionable recommendations for educators and policymakers.

Keywords: Game-Based Learning (GBL), Biology Education, Active Learning, STEM Education, Thailand Education Reform

Introduction

Game-based learning (GBL) in education is gaining traction as an active-learning approach in K-12 science education. By using interactive games instead of passive lectures, teachers build a classroom community where students can “problem-solve and collaborate,” making biology concepts easier and more engaging (Chang & Hwang, 2019). Recent pedagogical theories emphasizing 21st century skills and STEM practices reinforce experiential learning: students learn by doing and then reflecting (Kolb, 1984). In biology, board games can model

ecosystems or physiological systems, helping learners appreciate cause-and-effect relationships and stakeholder interactions (Gowithayakorn, 2023; Chirawat, 2023).

Recent research confirms that active, game-based strategies improve student attitudes and motivation toward science (Hamari et al., 2016). Games simulating ecological scenarios, for example, allow students to "embody various perspectives," fostering empathy and critical discussion about shared resources (Academic Bureau of Thailand, 2022). The interactive nature of games also supports diverse learning styles and cooperative learning (McGonigal, 2010; Srisuk, 2023). As a result, many educators consider board games a valuable complement to traditional instruction, creating meaningful learning experiences and deeper understanding (Altakhayneh & Abumosa, 2020).

However, integrating games into classrooms presents challenges. Teachers often require training to use games effectively, and schools need to allocate sufficient time and resources. There are also concerns about falling behind on curriculum coverage and uncertainty in assessing outcomes from game-based activities (Chirawat, 2023; McGonigal, 2010). Understanding how to navigate issues such as teacher readiness, resource allocation, curricular alignment, and assessment is crucial for realizing the full potential of GBL.

Existing literature broadly agrees that well-designed GBL can enhance engagement and collaboration in science education (Chang & Hwang, 2019; Hamari et al., 2016; Gowithayakorn, 2023). However, there are differing emphases between sources. Many international studies highlight cognitive gains and 21st-century skill development, whereas Thai research often stresses cultural relevance and teacher preparedness (Srisuk, 2023; Academic Bureau of Thailand, 2022). Both perspectives underscore the importance of aligning games with learning objectives, but they diverge on practical implementation priorities. This article aims to examine global trends and Thai implementations of game-based learning in high school biology education, with a focus on game design, classroom integration, and learning outcomes. Through a thematic review of recent studies and reports, we synthesize key findings to inform educators, policymakers, and future research.

Methodology

This paper presents an analytical literature review of recent research on game-based learning in high school biology. We conducted a systematic search of academic databases (Scopus, ERIC) and Thai research repositories (TCI Thai Journal Citation Index, education council

reports) using keywords such as “game-based learning,” “biology education,” “board games,” and their Thai equivalents. Sources were selected based on relevance to secondary-level biology education, including peer-reviewed articles, conference papers, theses, and government reports from 2010–2024. Studies focusing on other subjects or beyond K-12 settings were excluded. After screening titles and abstracts, approximately 30 sources meeting these criteria were analyzed in full. We then conducted content analysis, coding for themes related to game design principles, classroom implementation strategies, student engagement and learning outcomes, and implementation challenges. This thematic synthesis enables a comparative understanding of both global trends and Thai practices in biology GBL.

Findings

Game Design Principles for Biology Board Games

Effective educational games integrate design elements that align with learning goals. The literature identifies several key principles for science board games, including clear objectives, authentic scenarios, and interactive mechanics that model scientific concepts (Michelsen & Groß, 2024; Chirawat, 2023). Cooperative games, for example, have been found particularly effective in science education; by requiring players to work together to solve problems, they develop teamwork and negotiation skills (Srisuk, 2023). Chang and Hwang (2019) similarly note that well-designed games support cooperative learning outcomes by encouraging students to “collaborate in order to solve problems.”

Thematic content and narrative are equally important design considerations. Games themed around topics like rainforests or cellular biology provide real-world context that captures students’ interest. Even complex issues like climate change or resource management can be integrated into gameplay: some games allow students to simulate an ecosystem, making decisions as farmers, conservationists, or policymakers and thereby experiencing the trade-offs of sustainable development (Academic Bureau of Thailand, 2022; Gowithayakorn, 2023). Such contextual narratives help learners understand the social and ethical dimensions of biology, fostering empathy and critical thinking (Altakhayneh & Abumosa, 2020).

Game mechanics themselves also play a crucial role in engagement. Successful games balance challenge and skill level, providing appropriate scaffolding and feedback. They often include elements like resource allocation, random events, and decision-making that mirror scientific processes. For instance, progression in a game might involve moving through levels

or concepts while making choices and reflecting on outcomes, often aided by debrief discussions (Michelsen & Groß, 2024; Chirawat, 2023). When such mechanics align with clear learning outcomes (e.g., manipulating variables in a simulated experiment), students tend to engage more deeply.

Finally, incorporating culturally relevant design enhances game effectiveness in context. For example, scenarios reflecting challenges faced by Thai communities—such as managing local agricultural resources or conserving native species—make games more relatable and engaging for students (Srisuk, 2023). Studies indicate that games tailored to a specific culture create a stronger emotional bond with the material, improving knowledge retention (Office of the Education Council, 2024).

Implementation in the Classroom

Integrating board games into science lessons typically follows a multi-phase approach.

Phase 1 (Preparation): Teachers select or develop an appropriate game and prepare materials. This involves mapping game content to curriculum standards (e.g., specifying which biology concepts are targeted) and briefing students on rules. Many studies emphasize teacher readiness: educators need familiarity with the game's content and mechanics, as well as classroom management strategies for gameplay (Srisuk, 2023). Professional development or co-planning time can build this readiness, ensuring teachers feel confident facilitating play.

Phase 2 (Introduction): Teachers provide students with an overview of the game and often include a tutorial or demonstration round. Clear instructions and objectives help students grasp the game's learning goals. For example, one Thai study notes that a systematic introduction allows teachers to transition to a more observing role once students begin playing (Office of the Education Council, 2024). Linking the game to biological principles is crucial (e.g., "today's game will have you manage a garden's ecosystem"), which helps students focus on the instructional content during play.

Phase 3 (Engagement and Interaction): During gameplay, students actively take the lead. Board games naturally promote peer interaction, which is vital for collaborative learning (McGonigal, 2010). Many students and teachers report that the social aspects of gameplay enhance learning. For instance, students often "appreciate working as a team" to solve in-game challenges (Altakhayneh & Abumosa, 2020). The variety of experiences in a game (winning or losing, dealing with random events, negotiating with peers) enriches social dynamics and underscores the value of collaboration.

Incorporating reflective discussions after gameplay has also proven effective. Relating in-game experiences to biological concepts helps students gain deeper understanding and develop critical thinking skills (Hamari et al., 2016). For instance, after playing an ecosystem simulation, students may discuss how their choices as players reflect real-world impacts on biodiversity. Such debriefings are essential for turning gameplay into meaningful learning opportunities.

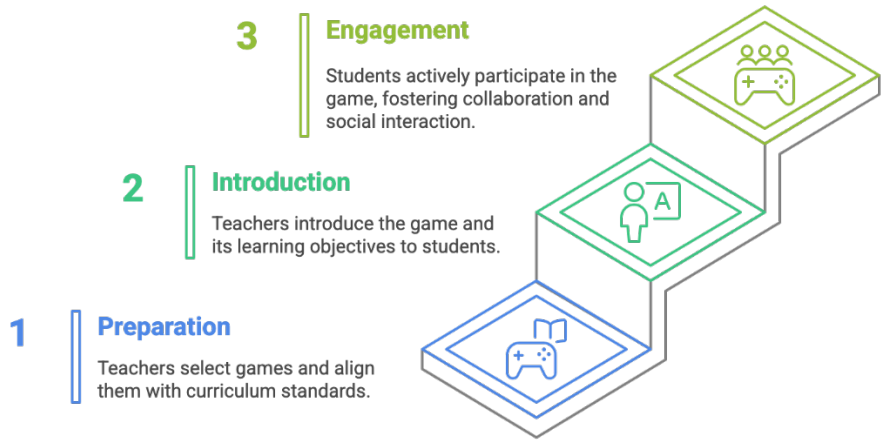

Figure 1 Implementing Game-based Learning

Annotation: The diagram, generated using Napkin.ai, illustrates the key phases of implementing game-based learning in high school biology education. It highlights Preparation, Introduction, and Engagement, showcasing the process of integrating board games into classroom activities.

Engagement and Learning Outcomes

Board games offer a key promise of enhanced student engagement. Multiple studies report that students find game-based lessons more enjoyable and motivating than traditional instruction (Hamari et al., 2016; Gowithayakorn, 2023). For example, one study found that nearly all junior high students enjoyed solving problems through board games. This heightened engagement often correlates with greater time-on-task and reduced off-task behavior (Office of the Education Council, 2024).

Research on learning outcomes is generally favorable, though sometimes mixed. Numerous studies using pre-post or quasi-experimental designs have found improvements in students' comprehension of specific concepts (such as food webs, genetics, or plant physiology) after playing educational games. The active problem-solving elements of these games allow players to "manipulate shared resources and discuss roles," which reinforces understanding of complex systems (Michelsen & Groß, 2024; Srisuk, 2023). Moreover, GBL can

support the development of 21st-century skills by engaging students in strategic decision-making, communication, and systems thinking.

Another finding is that narrative and emotional engagement can deepen learning. Games with stories or ethically challenging scenarios can evoke strong emotional reactions, improving conceptual understanding and memory retention (Academic Bureau of Thailand, 2022). For instance, a game that pits economic development against conservation can spark insightful discussions about ethics and sustainability in biology classes.

Case Studies and Examples

Internationally, several case studies illustrate the benefits of board games in STEM education. For example, a study in the Philippines integrated board games into the junior high math and science curriculum. After a series of sessions, 96.6% of students reported that the math games made learning fun, and this positive attitude was linked to improved performance. The authors concluded that “board games encourage enjoyment and deep discussion,” supporting their use in STEM classes (Altakhayneh & Abumosa, 2020). Although this example is in mathematics, it highlights a model applicable to science education as well.

In Thailand, documented classroom studies are still emerging. One small-scale project involved a university-developed biology board game on plant physiology, piloted in several schools and showing increased student interest (Chulalongkorn University, 2024). Moreover, Thailand’s Ministry of Education has emphasized active-learning pedagogy in its 2021–2030 education strategy, implicitly supporting methods like GBL (Rakha, 2025). Informal networks of Thai science teachers—such as blogs and social media groups—have also begun to share locally developed games. These trends suggest growing grassroots engagement with GBL in Thailand, even though formal research is still catching up.

Broader Asia-Pacific examples are also informative. A recent survey of innovative teaching found that countries encouraging collaborative, hands-on learning report higher student engagement, a trend that aligns with game-based approaches (Rakha, 2025). Similarly, a UNESCO Bangkok report (2022) noted game-based activities as promising tools for teaching complex socio-scientific issues in multicultural classrooms. Together, these cases underscore a common theme: game-based activities tend to draw in students, spark discussion, and create memorable learning experiences across diverse contexts. Success depends on thoughtful integration; as one Thai educator observed, even a simple ecology board game can become “a springboard for Socratic questioning” about sustainability.

Challenges in Implementation

Despite its benefits, implementing board games in education faces several challenges. A primary issue is teacher readiness. Many teachers have limited experience with game-based methods and may be unsure how to connect gameplay with learning objectives (Srisuk, 2023). Professional development and support are therefore essential; without proper training, teachers risk using games merely as rewards rather than as structured learning activities.

Resource limitations also pose a barrier. Some schools lack budgets to acquire new games or have insufficient classroom space for gameplay. Large class sizes—common in parts of Thailand—can make group-based games cumbersome. Teachers often adapt by creating low-cost, DIY games (using paper or simple materials), but this can dilute the gaming experience.

Curriculum alignment and time constraints are further concerns. In educational systems with tightly packed syllabi and high-stakes testing, teachers may fear that games take time away from "covering content." To address this, experts recommend integrating games within planned units (rather than as optional extras) and aligning them closely with mandated curriculum topics (for example, using a game instead of a worksheet on food chains).

Assessment of game-based learning outcomes is another challenge. Traditional standardized tests typically do not capture skills like teamwork or creative problem-solving that games develop. Teachers may need new assessment approaches—such as reflective journals or rubrics for collaboration—to evaluate these outcomes. Some models suggest asking students meta-cognitive questions after gameplay (e.g., "How did working with others in the game shift your perspective?") (McGonigal, 2010), but this requires additional time and planning.

Finally, the sustainability of GBL initiatives can be difficult. One-off game sessions have limited impact; studies indicate that repeated use and iterative gameplay are more effective. This means schools must commit to long-term integration of games into the curriculum, regularly updating game content as topics evolve. While some innovative schools and districts have begun such commitments, broad institutional support for GBL is still rare.

Discussion

The reviewed literature demonstrates consensus that game-based learning can enhance student engagement and collaboration, aligning well with active and experiential

learning principles. The social interaction in board games reflects constructivist and social learning perspectives, where collaboration is critical to knowledge construction (Chang & Hwang, 2019; McGonigal, 2010). However, few studies explicitly ground their GBL interventions in theoretical frameworks, suggesting an opportunity for future work to connect practice with theory.

In examining the literature, some limitations are apparent. Many studies report increased motivation or engagement but rely on small sample sizes or self-reported measures. Large-scale experimental research on GBL, especially in Thailand, remains scarce. Additionally, while Thai sources emphasize cultural relevance, detailed guidelines for designing culturally specific games are limited to anecdotal examples. This highlights a need for systematic evaluation of game designs across cultures.

For Thailand's education system, these findings have practical implications. The 2021–2030 educational reform emphasizes STEM education and 21st-century skills, which align with the strengths of GBL. To leverage this alignment, policy support is needed. Teacher education programs should include training on game-based pedagogies, and curricula may need to formally recognize game-based learning (Rakha, 2025). Developing assessment tools that capture collaboration and critical thinking will help validate GBL outcomes. Finally, partnerships among schools, universities, and educational agencies can facilitate pilot programs and generate local evidence on game-based learning's effectiveness in Thai classrooms.

Conclusion

This analytical review highlights that board game–based learning can be a powerful supplement to traditional biology education. The reviewed studies suggest that well-designed games accelerate student motivation, interest, and understanding of complex biological topics (Srisuk, 2023; Chirawat, 2023). In particular, gameplay fosters analytical thinking, collaboration, and other 21st-century skills by providing a risk-free, experiential context. These benefits align with Thailand's educational goals of conceptual learning and skills development.

However, realizing these benefits requires careful implementation. Teachers need access to well-designed games tied to specific learning objectives and must receive training and support. Schools and policymakers should allocate resources and curriculum time to integrate GBL meaningfully. The academic contribution of this article is to synthesize both international and Thai perspectives on game-based biology education, illuminating areas of

consensus and divergence. This comparative analysis contributes to the field by clarifying best practices and identifying gaps—particularly the need for more empirical research in the Thai context.

This review has some limitations. Our analysis is constrained by the availability of published studies: many Thai initiatives are informal or unpublished, and some studies rely on small samples or self-report measures. Future research should address these gaps by conducting rigorous, large-scale evaluations of GBL in Thai classrooms, including measures of long-term learning outcomes and cross-cultural validation of game designs. Additionally, exploring emerging trends such as digital game-based learning could be valuable.

In summary, with appropriate support and continued research, game-based learning has the potential to enhance biology education in Thailand and beyond by engaging students in active, meaningful learning.

Recommendations

Based on this literature review, we suggest several implications for practice and policy:

1. Professional Development Provide educators with training and resources on how to create and use educational games, including guidance on aligning games with curriculum standards.
2. Resource Sharing Develop repositories (online or print) of open-source game templates and vetted biology games. Foster professional networks where teachers can share playtesting experiences and success stories.
3. Curriculum Integration Encourage schools and educational authorities to formally incorporate GBL into science curricula. For example, allocate dedicated class time each term for game-based activities linked to key biology topics.
4. Assessment Innovation Adopt diverse assessment methods (e.g., projects, group presentations, portfolios, and reflection prompts) that capture learning from games. These methods should measure skills like collaboration and problem-solving, not just content memorization.
5. Research and Evaluation Promote collaboration between educators and researchers to study the impact of specific games in local classrooms. Collect data on student engagement, motivation, and learning outcomes to guide future improvements.

References

Academic Bureau of Thailand. (2022). *Integrated learning: Examples of using games for education in Thai schools*. Bangkok: Ministry of Education.

Altakhayneh, B., & Abumosa, M. (2020). Attitudes of university students towards the STEM approach. *International Journal of Technology in Education, 3*(1), 39–48. https://doi.org/10.46328/ijte.v3i1.16

Chirawat, S. (2023). *Educational games in the digital age: Innovations for 21st-century skills development*. Bangkok: Kasetsart University Press.

Chang, C. Y., & Hwang, G. J. (2019). Trends in digital game-based learning in the mobile era: A systematic review of journal publications from 2007 to 2016. *International Journal of Mobile Learning and Organisation, 13*(1), 68 - 90. https://doi.org/10.1504/ijmlo.2019.10016603

Chulalongkorn University. (2024). *Impact of game-based learning on student engagement in high school biology: A case study*. Bangkok: Chulalongkorn University Press.

Gowithayakorn, T. (2023). Game-based learning innovation to development of analytical thinking ability. *ASEAN Journal of Education, 6*(1), 8–15. Retrieved from https://so01.tci-thaijo.org/index.php/AJE/article/view/269787

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior, 54*, 170–179. http://dx.doi.org/10.1016/j.chb.2015.07.045

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.

McGonigal, J. (2010). Power-ups: How games can save our students' (and teachers') lives. *Journal of Educational Game Design, 4*, 15–30. https://doi.org/10.1080/10875300802103874

Michelsen, M., & Groß, J. (2024). Peer interaction – collaborative learning to foster and observe conceptual transformation in science education. *Journal of Biological Education*, 1–21. https://doi.org/10.1080/00219266.2024.2386251

Office of the Education Council. (2024). *Developing scientific skills through classroom games: A research report from Bangkok schools*. Bangkok: Office of the Education Council.

Rakha, A. (2025). Promoting online teaching through active learning strategies: Applications and innovations. *Frontiers in Education, 10*. https://doi.org/10.3389/feduc.2025.1546208

Srisuk, K. (2023). Learning management and classroom assessment competency of teachers according to education reform policy in Thailand: A case study of schools in the Chiang Mai education sandbox. *Kasetsart Journal of Social Sciences, 45*(1), 43–52. Retrieved from https://so04.tci-thaijo.org/index.php/kjss/article/view/269467

UNESCO Bangkok. (2022). *Innovative education for sustainable development in Asia-Pacific: Leveraging games and simulations*. Bangkok: UNESCO Regional Bureau for Education in Asia and the Pacific. https://unesdoc.unesco.org/ark:/48223/pf0000378900