Review

Educational Board Game Design and Implementation for Complex Secondary Student Skills: A Rapid Review

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Posted Date: 29 August 2025

doi: 10.20944/preprints202508.2159.v1

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 doi:10.20944/preprints202508.2159.v1

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Educational Board Game Design and Implementation for Complex Secondary Student Skills: A Rapid Review

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Abstract

Background: Secondary education is increasingly challenged to develop complex cognitive and social skills such as systems thinking, argumentation, and collaboration through traditional methods. Educational board games present a promising alternative, blending engagement with advanced learning opportunities. **Methods**: This rapid review compiled evidence from 14 key studies and systematic reviews published from 2013 to 2025, focusing on design frameworks, implementation strategies, and the educational effectiveness of board games that target complex skill development in secondary students aged 11-18. **Results**: The field has progressed from relying on theoretical frameworks to adopting evidence-based design methods. Notable discoveries include validated frameworks that support low-workload implementation for teachers, systematic linkages between game mechanics and learning objectives, and substantial evidence demonstrating enhanced student engagement and learning outcomes across various subjects. Nonetheless, notable gaps still exist in areas such as embedded assessment, teacher professional development, and equity considerations. **Discussion**: Educational board games have real potential for fostering complex skills that traditional teaching often cannot fully develop. Achieving success depends on consistent support for teachers, proper curriculum integration, and aligned assessment strategies. Key research areas should focus on embedded assessment methods, scalable training for educators, and studies on long-term impact.

Keywords: educational board games; secondary education; complex skills; game-based learning; cooperative learning

1. Introduction

Secondary education systems worldwide face a core challenge in equipping students for a future that's becoming more complex and collaborative. Although traditional teaching methods successfully convey factual knowledge and simple procedures, they often fall short in fostering the advanced cognitive and social skills needed for 21st-century competence. These skills include systems thinking (understanding how various parts of a problem interact), argumentation (building and defending evidence-based reasoning), collaborative problem-solving (working well with others to tackle difficult issues), and metacognitive reflection (monitoring and adjusting one's own thinking processes) [1,2].

The limitations of traditional teaching methods for cultivating these advanced skills have led educational researchers to seek alternative strategies that balance engagement and rigor. Educational board games have become a promising solution because they inherently integrate key elements vital for deep learning: hands-on interaction with tangible materials, genuine social exchanges, rule-based problem-solving, and instant feedback from outcomes [1,3,4].

 doi:10.20944/preprints202508.2159.v1

Educational board games are grounded in well-established learning theories. Constructivist learning suggests that students learn best when actively building knowledge, such as by manipulating physical objects that symbolize abstract ideas [3,5]. For instance, moving game pieces, managing resources, or handling cards that depict scientific phenomena encourages active involvement and understanding, aligning with constructivist principles. Meanwhile, self-determination theory highlights the motivational aspects of these games, as they naturally foster autonomy (control over choices), competence (feeling capable), and relatedness (social connection), which support intrinsically motivated learning [6,7].

Social constructivism highlights how the collaborative nature of board games fosters peer learning, shared meaning-making, and group problem-solving that go beyond individual knowledge. Importantly for practical use, advanced frameworks have been developed to connect game mechanics to specific learning goals systematically. Examples include the MDA model (Mechanics-Dynamics-Aesthetics) and the LM-GM framework (Learning Mechanics-Game Mechanics), which shift the field from intuitive design to an evidence-based approach [1].

Despite increasing enthusiasm for educational board games, there is a lack of comprehensive synthesis regarding effective design, implementation, and assessment strategies. Many studies concentrate on particular subjects or contexts, which makes it challenging for educators and researchers to identify broader patterns and principles for improving practice. Furthermore, the field's rapid development, including the rise of hybrid digital-physical games, calls for updated analyses of existing capabilities and future opportunities.

This rapid review seeks to answer several key questions: (i) Which design frameworks and principles are most effective for developing educational board games aimed at secondary students? (ii) How do certain game mechanics contribute to the development of complex cognitive and social skills? (iii) What strategies and teacher roles facilitate successful implementation in classrooms? (iv) What evidence supports the educational effectiveness of board games in secondary education? (v) What challenges exist today, and what future opportunities are emerging in this area?

This review covers both traditional analog board games and new hybrid digital-physical formats, emphasizing games that foster complex skill development rather than basic content delivery. It analyzes secondary education settings for ages 11-18 across various subjects such as mathematics, sciences, history, and computer science, with a focus on practical factors that influence real-world adoption and effectiveness.

2. Methods

Study Identification and Selection

This rapid review was conducted following established guidelines for educational research synthesis, with modifications tailored to the emerging and interdisciplinary field of educational board game studies. It aimed to identify and analyze the most significant contributions to understanding how educational board games support the development of complex skills in secondary education environments.

Search Strategy: A comprehensive search was performed using the Semantic Scholar database, which contains approximately 200 million scholarly items. This platform aggregates metadata and full-text content from primary scholarly sources, including PubMed/Medline, arXiv, CrossRef-indexed journals, the Directory of Open Access Journals (DOAJ), Microsoft Academic Graph legacy data, various university repositories, and numerous publisher feeds. The search included terms like "educational board games," "secondary education," "complex skills," "game-based learning," and "collaborative learning," combined with Boolean operators and related keywords to ensure the retrieval of relevant literature.

Inclusion Criteria: Studies were included if they met these criteria: (i) focused on educational board games, including hybrid digital-physical formats, used in secondary education (students aged 11-18); (ii) targeted complex cognitive or social skills rather than just content memorization; (iii)

 doi:10.20944/preprints202508.2159.v1

provided empirical evidence, systematic frameworks, or thorough theoretical analysis; (iv) published between 2013 and 2025 to reflect the recent growth of the field; and (v) available in English with enough detail for analysis.

Exclusion Criteria: Studies were excluded if they primarily focused on elementary education, involved only digital games without physical components, targeted only basic skills such as vocabulary practice, lacked a detailed methodology, or provided only preliminary, unsupported findings.

Study Selection Process: The initial search identified about 200 potentially relevant studies. After eliminating duplicates and applying inclusion/exclusion criteria, 14 key studies and systematic reviews were selected for their comprehensive and significant contributions to the field. These works originate from various geographical regions, employ different methodological approaches, and cover diverse subject areas, all while focusing on secondary education and the development of complex skills.

Data Extraction and Analysis

Framework Development: A systematic framework was created to gather and structure information across various dimensions: (i) theoretical foundations and design principles; (ii) game mechanics and learning objectives; (iii) implementation strategies and teacher roles; (iv) assessment and evaluation methods; (v) evidence of educational effectiveness; and (vi) challenges and limitations identified.

Synthesis Approach: Data synthesis employed a narrative method suitable for the diverse methodological and theoretical perspectives in the literature. Findings were organized thematically, with consideration for the field's evolution over time and the diverse research contexts. Emphasis was placed on highlighting common findings across studies while also noting disagreements or areas with limited evidence.

Limitations

This rapid review has significant limitations to consider when interpreting the findings. Focusing solely on English-language publications may have excluded relevant research published in other languages. The limited number of core studies suggests that the field is still in development, which also restricts the broad applicability of the results. Including both empirical research and theoretical frameworks provides an exhaustive overview, but makes it more challenging to compare evidence quality directly. Additionally, while suitable for emerging areas, the rapid review method does not offer the comprehensive coverage of a full systematic review.

3. Results

3.1. Overview of Included Studies

This review examines 14 core studies that reflect a decade of development in educational board game research, from foundational theories in 2013 to advanced empirical studies in 2025. The studies reveal notable diversity in geographic scope, with research conducted across Asia (the Philippines, Taiwan, and Japan), Europe (Denmark, Germany, Portugal, and Finland), and North America, underscoring the global interest in educational board games.

The included studies employ various methods, including design-based research with iterative classroom testing [3,9–11], quasi-experimental trials with control groups [5,6], detailed qualitative video micro-analysis [8,12], and comprehensive systematic reviews that synthesize numerous studies [1,2]. This methodological variety provides diverse insights into the effectiveness of educational board games, highlighting the complexity involved in assessing game-based learning approaches.

Subject area coverage includes mathematics [3], physics and astronomy [4,5], history [6], computer science [9,11], chemistry [13], English language arts [10], and general collaborative skills

 doi:10.20944/preprints202508.2159.v1

[8,12]. This range demonstrates that educational board games can be effectively adapted for various academic fields, although their specific implementation and assessment methods differ significantly based on subject-specific learning goals and limitations.

The research's evolution over time reveals three distinct stages, indicating the field's growth. The initial establishment (2013-2015) focused on creating basic frameworks and tailoring existing theories to the context of board games [13,14]. The expansion and empirical application phase (2014-2019) involved classroom pilot tests, iterative game development, and systematic evaluation [5,10]. The latest phase, theoretical consolidation (2020-2025), encompasses thorough, systematic reviews and unified frameworks that address both design and implementation issues [1–3]. Table 1 provides a comprehensive overview of the characteristics and key contributions of all 14 core studies included in this review.

Table 1. Characteristics of Included Studies.

Ref	Study	Year	Country/Region	Subject Area	Research Method	Sample/Scope	Duration	Key Findings/Contributions
[1]	Katsantonis	2025	Multi-national	Cooperative gaming (generic)	Systematic review	24 studies analyzed	N/A	Framework for cooperative mechanics; identifies variable player powers and role-playing as key elements
[2]	Hashim et al.	2023	Malaysia	Science education	Systematic review	65 studies screened	N/A	Comprehensive synthesis of board games in science education; identifies implementation gaps
[3]	Nautiyal et al.	2024	Philippines	Mathematics	Design-based research	45 K-12 students	6 weeks	Validated "Let's Get On-Board" framework; demonstrated low teacher workload integration
[4]	Cardinot & Fairfield	2019	Ireland	Physics & Astronomy	Mixed methods	119 post-primary students	Multiple sessions	Significant knowledge gains in astronomy

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								concepts; improved perceptions of scientists
[5]	Low et al.	2024	Malaysia	Physics	Mixed methods case study	41 upper secondary students	Multiple sessions	"Catch the Flight" game enhanced understanding of force resolution; positive player experience
[6]	Li et al.	2021	Taiwan	History	Quasi-experimental	29 senior school students	4 weeks	AR dual-scaffolding improved learning performance and flow state in local history
[7]	Lin et al.	2021	Taiwan	Health Education	Quasi-experimental	High school students	Multiple sessions	AR integration increased motivation and technology acceptance in health education
[8]	Hanghøj & Karnøe	2024	Denmark	Collaboration skills	Qualitative analysis	Upper secondary students	Extended observation	Detailed video microanalysis of collaborative discourse patterns in cooperative play
[9]	Wulandari et al.	2023	Indonesia	Computer Science	Framework development	Teachers and researchers	N/A	Five-stage hands-on development framework for computer network education
[10]	Zhu	2014	China	English Language Arts	Case study	Senior high school class	Multiple lessons	"Can Anne Go Upstairs" demonstrated vocabulary

 doi:10.20944/preprints202508.2159.v1

								learning and motivation enhancement
[11]	Yang & Kopcha	2022	USA	Computer Science	Design-based research	Beginning programmers	4 prototype cycles	Board game development for block-based programming; iterative design insights
[12]	Erdogan et al.	2022	Turkey	Strategic thinking	Framework development	Classroom settings	N/A	Phase-specific teacher mediation framework for strategic board games
[13]	Tuomisto & Aksela	2015	Finland	Chemistry	Framework development	Lower secondary focus	N/A	Design and evaluation framework for chemistry card/board games; literature-based
[14]	Sousa	2013	Portugal	Generic adaptation	Framework development	Teachers/researchers	2 workshop sessions	MBGTOTEACH framework for adapting modern board games; teacher-centered approach

As shown in Table 1, the studies included exhibit notable methodological diversity. Systematic reviews synthesize findings across the field [1,2], design-based research provides insights into iterative processes [3,9,11], and quasi-experimental studies present evidence of controlled effectiveness [4,6,7]. The research spans multiple continents, covering a range of subjects from specific disciplines like mathematics and chemistry to broader skills in collaboration and strategic thinking. The timeline from 2013 to 2025 reflects the field's progression from initial framework development [13,14], through empirical validation [4,5,10], to recent efforts in theoretical consolidation [1–3].

3.2. Design Frameworks and Approaches

The research identifies several validated frameworks that offer systematic guidance for developing educational board games. Among them, the "Let's Get On-Board" framework by Nautiyal et al. stands out as the most thoroughly tested. It emphasizes integrating design and classroom

 doi:10.20944/preprints202508.2159.v1

implementation from start to finish, with a focus on reducing teacher workload [3]. This framework has been effectively piloted in Philippine mathematics classes, showing significant learning improvements and earning positive reviews from both teachers and students.

The MBGTOTEACH framework employs a distinct approach, viewing teachers as active designers who modify existing commercial games for educational purposes [14]. It acknowledges that many complex hobby games incorporate mechanics that can be educationally beneficial if adapted appropriately for classroom settings. The framework provides systematic guidance to help educators select promising games and modify them in a structured manner, moving away from reliance on intuition or trial-and-error methods.

Subject-specific frameworks have developed to tackle the unique challenges of various academic fields. The ADDIE plus Playful Learning Integration framework has shown particular effectiveness in STEM education, blending traditional instructional design principles with elements tailored to game-based learning [5]. This strategy led to the creation of "Catch the Flight," a physics board game that enables students to grasp complex ideas about forces and motion through hands-on interaction.

Chemistry education has gained from tailored evaluation frameworks that adapt digital game assessment standards for physical board and card games [13]. These frameworks focus on translating abstract chemical ideas into tangible game mechanics, making molecular interactions manipulable and comprehensible through gameplay instead of remaining purely theoretical.

Across all frameworks, several key design principles have emerged that set effective educational board games apart from mere entertainment products. Ensuring low teacher workload is essential, as even well-designed pedagogical games will fail if they demand significant prep or specialized knowledge that educators do not possess [3,14]. Proper curriculum integration guarantees that games enhance existing instruction without disrupting coverage of key content. Additionally, iterative development involving educator feedback is vital, as successful educational game design requires multiple testing, evaluation, and refinement cycles based on real classroom experience rather than just theoretical ideas.

3.3. Game Mechanics and Learning Relationships

Mapping specific game mechanics to learning objectives is a breakthrough in educational board game research. Research has shown clear links between certain mechanical elements and the growth of complex cognitive and social skills, which are essential for effective secondary education.

Developing systems thinking is especially enhanced by mechanics such as resource flows, feedback loops, and puzzle elements that compel students to analyze multiple variables simultaneously [4,5]. In physics education, games that task students with managing force distribution across various spacecraft systems help students understand the interactions and influences of different physical variables over time. These mechanics transform abstract systems thinking into tangible and manipulable experiences, enabling students to experiment with complex relationships in ways that traditional teaching methods often cannot easily provide. Table 2 systematically presents the empirically supported relationships between specific game mechanics and targeted learning objectives identified across the reviewed studies.

Table 2. Game Mechanics to Learning Objectives Mapping.

Learning Objective	Primary Game Mechanics	Mechanism of Action	Supporting Evidence	Example Implementation	Subject Applications
Systems Thinking	• Resource flow management • Feedback loops • Interconnected	Players must consider multiple variables simultaneously;	[4,5]	"Catch the Flight" - force allocation across spacecraft systems affects	Physics, Environmental

 doi:10.20944/preprints202508.2159.v1

	decisions • Puzzle elements	observe cause-effect relationships over time; manage competing demands		multiple trajectory variables	Science, Engineering
Collaborative Problem-Solving	• Cooperative victory conditions • Variable player powers • Hidden information sharing • Asymmetric capabilities	Success requires coordinated action; players develop communication protocols; leverage diverse strengths and perspectives	[1,8]	Pandemic-style games where players have unique roles but shared objectives	Generic, Science, Social Studies
Argumentation Skills	• Evidence gathering mechanics • Peer explanation requirements • Justification of strategic choices • Debate-style card play	Players collect supporting information; must defend decisions with reasoning; engage in evidence-based discourse	[6]	AR history games with dual-scaffolding - collect evidence then argue historical positions	History, Science, Literature
Metacognitive Reflection	• Strategic turn-based play • No-luck decision points • Consequence analysis • Planning ahead requirements	Players must evaluate alternatives; reflect on decision effectiveness; develop strategic awareness	[12]	Abstract strategy games like Pentago - pure strategy forces reflection on thinking processes	Mathematics, Logic, General reasoning
Mathematical Thinking	• Structured revision mechanics • Problem-solving frameworks • Quantitative resource management • Computational challenges	Mathematical concepts embedded in game actions; repeated practice in engaging context	[3]	Board games for math revision - problem-solving integrated into gameplay mechanics	Mathematics, Statistics, Economics

 doi:10.20944/preprints202508.2159.v1

Historical Reasoning	• Evidence-based narrative construction • Multiple perspective role-play • Primary source integration • Temporal sequence mechanics	Players reconstruct historical events; consider multiple viewpoints; work with authentic materials	[6]	Local history games with AR overlays revealing primary sources and multiple narratives	History, Social Studies, Civics
Computational Thinking	• Algorithm representation • Logic sequence building • Programming concept metaphors • Debugging mechanics	Abstract programming concepts made concrete through physical manipulation and visual representation	[9,11]	Board games using physical pieces to represent code blocks, variables, and program flow	Computer Science, Logic, Mathematics
Scientific Reasoning	• Hypothesis testing mechanics • Variable manipulation • Data collection and analysis • Experimental design elements	Players form predictions; test ideas through gameplay; observe patterns and draw conclusions	[4,5]	Astronomy games where players test understanding of celestial mechanics through gameplay predictions	Physics, Chemistry, Biology, Earth Science

Table 2 highlights the evolution of research on educational board games, showing a shift from intuitive design methods to evidence-based strategies that map specific mechanics to learning outcomes. It indicates that different learning goals require tailored mechanical approaches: for instance, systems thinking is enhanced by resource management and feedback loops [4,5], while collaborative problem-solving is promoted through cooperative victory conditions and asymmetric player abilities [1,8]. Importantly, advanced skill development is most effective when multiple mechanics operate together synergistically. A case in point is the dual-scaffolding method used in AR history games, which combines evidence-gathering mechanics with peer explanation tasks to foster both individual research skills and collaborative argumentation [6].

The subject-specific applications show how these general mechanics-learning relationships can be adapted across disciplines while maintaining their core educational effectiveness. Mathematics education leverages structured revision mechanics [3], while computer science education uses programming concept metaphors [9,11], yet both rely on the fundamental principle that abstract concepts become accessible through concrete, manipulable game elements.

 doi:10.20944/preprints202508.2159.v1

Collaborative problem-solving arises from conditions such as cooperative victory goals, varied player abilities, and hidden information mechanics, which foster genuine interdependence among players [1,8]. When success depends on coordinated efforts, students tend to develop communication protocols, conflict resolution skills, and shared decision-making, all of which promote genuine social skills. The uneven skills in cooperative games compel students to utilize their unique strengths and coordinate diverse strategies, reflecting the collaborative skills emphasized in both academic and professional settings.

Argumentation skills are enhanced by mechanisms that involve gathering evidence, explaining to peers, and justifying strategic decisions [6]. The dual-scaffolding method employed in augmented reality history games sets up scenarios where students collect historical evidence during gameplay and subsequently use this evidence to support their arguments in peer discussions. This blend of personal research and teamwork reflects the evidence-based argumentation typical of disciplinary thinking in history and other academic areas.

Metacognitive skills are fostered through strategic turn-based games that compel students to plan, compare options, and reflect on their decision-making. No-luck strategic games particularly encourage students to take ownership of outcomes and analyze their choices, promoting awareness of their thought processes that can be applied to broader academic situations.

These mechanics differ considerably across various subjects, each providing distinct opportunities for designing educational games. In mathematics, structured revision techniques and problem-solving frameworks enable students to practice mathematical thinking in engaging ways [3]. History education has advanced through the use of augmented reality, which enriches traditional mechanics with digital scaffolding that fosters evidence-based reasoning [6]. Computer science education has effectively used mechanics that replicate programming logic, employing physical game pieces to symbolize abstract computational ideas [9,11].

3.4. Implementation Strategies and Teacher Roles

Effective classroom use of educational board games relies on a nuanced understanding of teacher facilitation, logistical challenges, and support systems within institutions. Studies have outlined a progression of teacher roles, ranging from director to coach to game master, with each role suited to specific situations and learning goals [3,12].

The director's role involves frequent teacher intervention to correct misconceptions, redirect attention, and ensure alignment with learning objectives. While this approach is necessary when introducing new games or working with students who need more structure, too much guidance can diminish the autonomous decision-making that makes games educationally impactful. The coach role strikes a balance by offering guidance and support while giving students ample freedom to explore and learn from their mistakes. Successful coaching depends on knowing when to intervene with strategic questions and when to let students engage in productive struggle.

The gamemaster role involves teachers serving mainly as facilitators who keep the game flowing, explain rules, and create the best conditions for learning without directly controlling student choices. This method can be especially effective for building student independence and teamwork skills, although it requires teachers to be comfortable with less predictable classroom dynamics [8].

Detailed frameworks for structured teacher mediation offer clear guidance across various stages of educational gameplay [12]. Successful implementation involves thorough pre-briefing to prepare students on game mechanics and learning goals, strategic facilitation during gameplay that emphasizes observing and questioning over direct instruction, and organized post-play debriefing to encourage students to reflect on their learning and link game experiences to larger educational aims.

Logistical constraints play a crucial role in the successful implementation of projects and must be navigated carefully. The typical secondary school period, lasting 45 to 60 minutes, necessitates games that fit within a single session, feature save-state mechanisms for multi-session gameplay, or use simplified rules that reduce setup time [3,5]. Additionally, grouping strategies should balance pedagogical goals—such as ensuring a mix of skill levels—with practical considerations like

 doi:10.20944/preprints202508.2159.v1

classroom space, noise control, and the teacher's capacity to oversee multiple games simultaneously [3,8].

Material costs and accessibility remain ongoing challenges, especially for schools serving economically disadvantaged communities. Successful solutions often involve innovative strategies such as student-made game parts, collaborations with local organizations, and print-and-play options that can be easily reproduced with standard school resources [1,2].

3.5. Assessment and Evaluation Methods

Current methods in educational board game research mainly depend on traditional pre-test and post-test setups, along with qualitative observations and interviews [4–6]. These quantitative tools have shown notable learning improvements across various subjects, as students perform better on concept inventories, problem-solving tests, and standardized assessments of their specific subject knowledge.

Motivation and engagement surveys, such as the Instructional Materials Motivation Survey and the Technology Acceptance Model, consistently indicate that students respond favorably to well-designed educational board games [6,7]. When students participate in board games, they tend to show increased intrinsic motivation, maintain better focus, and develop more positive attitudes toward learning compared to conventional teaching methods.

The most advanced assessment methods include detailed video analysis of student interactions during gameplay. This approach uncovers collaborative discourse patterns and the development of strategic reasoning, which traditional testing methods might miss [8]. Micro-analysis of communication during cooperative board games shows the emergence of negotiation strategies, evidence-based reasoning, and metacognitive reflection, all indicating real skill development rather than just superficial involvement.

However, large assessment gaps restrict both research insights and practical use. Without embedded or "stealth" assessments, evaluations usually interrupt gameplay instead of gathering insights directly from game activities [1,2]. This creates artificial divides between learning and assessment, which may undervalue the educational benefits of board game experiences.

The absence of analytics-based metrics is a significant limitation as digital technologies become more embedded in traditional board games. Although hybrid augmented reality games produce detailed data on student interactions and choices, most research does not utilize this information for assessment. The opportunity for real-time learning analytics to enhance both student learning and teacher facilitation is still largely unmet.

3.6. Technology Integration and Hybrid Formats

The rise of hybrid educational board games, which blend physical parts with digital tech, marks a significant innovation in the field. Augmented reality integration has shown great potential, with the dual-scaffolding method illustrating how digital overlays can improve traditional board game learning while preserving the tactile and social advantages that make physical games valuable [6].

The Card-Slide-Learning-Sheet model provides a comprehensive framework for integrating printed materials, projected content, and augmented reality cues to create multi-layered learning environments [7]. Students engaging with this method in health education experienced notably higher motivation and greater acceptance of technology, while preserving the collaborative advantages associated with physical board games.

Technical implementation has advanced as mobile device capabilities grow and augmented reality tools become more accessible. Modern smartphones and tablets can recognize printed markers on game pieces, activating digital content that seamlessly integrates with the physical components. This combination retains the tactile manipulation that enhances the educational value of board games while incorporating digital features that can't be achieved with purely analog methods.

Hybrid formats offer advantages beyond merely delivering content, such as real-time data collection, flexible content adjustment, and multimedia use that help make abstract ideas more

 doi:10.20944/preprints202508.2159.v1

tangible and engaging [6,7]. However, they also pose challenges like device access issues, cognitive load management, and the need for teachers to be skilled in troubleshooting educational technology.

The balance between physical and digital elements presents a key design challenge. Digital parts that overly dominate can diminish the main advantages of learning through board games, whereas too little digital integration might not justify added complexity and costs [7]. Effective hybrid games find a careful balance, leveraging digital technology to support, not replace, the essential features of physical gameplay.

3.7. Evidence for Educational Effectiveness

The accumulated evidence supporting the effectiveness of educational board games consistently shows positive results across various learning aspects and educational settings. Quantitative research indicates notable improvements in subject-specific assessments, with students performing better on concept inventories, problem-solving exercises, and standardized academic achievement tests [3–6].

Research in astronomy education shows compelling evidence that students engaged in board game activities exhibit measurable gains in grasping celestial mechanics, planetary relationships, and scientific reasoning, which are often challenging to attain via traditional teaching methods [4]. Likewise, physics education research highlights comparable advantages, with students playing games such as "Catch the Flight" demonstrating improved comprehension of forces, motion, and systems thinking through hands-on interactions and group discussions [5].

Mathematics education research indicates that board games can enhance both content mastery and problem-solving abilities, with students achieving better scores on standardized tests and showing increased motivation along with decreased math anxiety [3]. In computer science education, there is especially strong evidence that board games effectively foster computational thinking and programming skills, as students demonstrate improved coding performance and a better grasp of algorithms [9,11].

Qualitative evidence highlights complex learning processes that quantitative metrics often overlook. Video analysis of cooperative gameplay shows how students develop collaborative discourse, strategic reasoning, and social problem-solving skills that reflect real educational progress [8]. They naturally create communication protocols, conflict resolution strategies, and shared decision-making approaches that go beyond the game, impacting broader academic and social situations.

The motivational advantages of educational board games are consistently shown in research, with students indicating greater engagement, intrinsic motivation, and positive attitudes toward learning than traditional teaching methods [5–7]. These emotional benefits are especially crucial in secondary education, where student disengagement can become a major obstacle to learning success.

However, the evidence base also shows significant limitations that impact how we interpret and generalize the findings. Many studies feature small samples or only short-term interventions, which restricts our understanding of long-term retention and transfer effects [2]. Although pilot studies and design-based research offer valuable insights into learning processes, their prevalence makes it challenging to assess their overall effectiveness and determine the most effective implementation methods.

4. Discussion

4.1. Key Findings and Implications

An analysis of 14 key studies shows that educational board games are a promising method for enhancing complex cognitive and social skills in secondary students. However, their success depends on thoughtful design, proper teacher training, and ongoing evaluation. Over the last decade, the field has evolved from initial enthusiasm and theory to evidence-based approaches that demonstrate clear educational gains, even as some implementation issues persist.

 doi:10.20944/preprints202508.2159.v1

The key discovery is the systematic link between specific game mechanics and targeted learning outcomes. Unlike previous methods that assumed any engaging game would naturally encourage learning, recent research shows that certain mechanic elements can be intentionally crafted to develop specific cognitive and social skills [1]. For example, cooperative victory conditions reliably foster teamwork, resource management mechanics cultivate systems thinking, and evidence-gathering tasks improve argumentation skills. This mechanistic insight offers a scientific basis for designing educational games that can be consistently replicated and improved, rather than relying solely on individual creativity or intuition.

The evidence supporting educational effectiveness is especially strong because it covers multiple subjects, diverse student groups, and various research methods. Students consistently demonstrate improved learning outcomes, increased motivation, and more advanced skills when using well-designed educational board games [3–6,8]. These advantages appear genuine rather than merely due to novelty, as they persist over long-term use and are supported by thorough qualitative analysis of learning processes.

Most notably, educational board games appear to address core issues in secondary education that conventional teaching methods struggle to resolve. By merging hands-on activities, genuine social interactions, and instant feedback, these games foster learning environments where advanced skills such as collaboration, systems thinking, and strategic reasoning develop organically through engaging gameplay, rather than through direct instruction or artificial practice drills [1,5,8].

4.2. Persistent Challenges and Limitations

Although there is promising evidence of educational benefits, key obstacles still hinder research progress and the practical use of educational board games. The primary challenge is that current assessment methods are insufficient for measuring the complex and collaborative learning experiences these games aim to foster [1,2].

Traditional testing methods emphasize individual knowledge and procedural skills but often overlook the collective abilities, social learning, and contextual understanding that are the key educational benefits of board game experiences. This gap in assessment presents practical challenges for teachers, who must demonstrate student progress within accountability systems that demand measurable individual results. It also hampers research efforts to understand how and why educational board games facilitate learning.

Teacher preparation and ongoing professional development remain significant challenges that impact both the quality of research and its scalability in practice. Successful facilitation of board games depends on gaming literacy, a deep understanding of collaborative learning, and knowledge of how mechanics align with educational goals [1,12,14]. However, most teachers lack these skills and do not receive sufficient professional development to develop them, which hinders the effective use of educational board games despite schools' investment.

The scalability issues encountered when transitioning from small pilot studies to larger deployments remain largely unresolved. Games that perform well with expert facilitation and specialized student groups may behave quite differently in typical classrooms, which are constrained by standard time and resources [1,3]. The field does not yet fully understand which implementation components are critical for sustaining educational effectiveness and which can be modified to fit local contexts without harming learning results.

Equity and inclusion have been insufficiently addressed, despite their clear importance for educational fairness and effectiveness. Many board games include cultural assumptions, complex language requirements, and social dynamics—whether competitive or cooperative—that can benefit some students while placing others at a disadvantage. Current research has not thoroughly explored these disparities. This is especially worrisome because board games often involve intricate social interactions and cultural knowledge, which may not be equally accessible to all students.

Methodological limitations in current research pose additional challenges for assessing effectiveness and informing practice. Small sample sizes primarily restrict generalizability, and the

 doi:10.20944/preprints202508.2159.v1

absence of long-term follow-up studies hampers understanding whether learning gains are sustained over time or transferred to new situations [2]. Moreover, inconsistent reporting standards across studies complicate the comparison of results, replication of research, and synthesis of evidence from multiple investigations.

4.3. Future Directions and Opportunities

The field of educational board game research and practice is likely to make significant progress in the coming decade, driven by technological advances, shifting educational goals, and growing research complexity. The current prime opportunities focus on combining hybrid digital-physical methods that maintain the tactile and social advantages of classic board games, while also utilizing digital tools for real-time evaluation, adaptive content, and multimedia features.

Developing embedded assessment methodologies is likely the most vital research focus, as it tackles practical barriers and deepens understanding of learning processes. Future studies should design assessment methods that derive meaningful insights directly from gameplay, instead of using separate tests that might overlook key educational gains [1,2]. The advancement of learning analytics and the blending of digital tech with physical games offer unique opportunities to create these integrated approaches.

Scalable teacher professional development is becoming increasingly important. It involves systematically identifying the knowledge and skills educators need for effective facilitation, as well as developing efficient methods to help teachers acquire these abilities. Additionally, sustainable systems are essential for ongoing support and improvement [1,14]. The most effective strategies involve collaborative design processes, where teachers jointly create, test, and refine educational board games, rather than relying solely on externally designed materials.

Long-term retention and transfer studies are essential to determine if the learning gains observed in short-term pilots last over time and extend to new contexts beyond specific game experiences [2]. This research would offer crucial evidence to justify the investment of time and resources for effective implementation and help clarify how learning from board games connects to wider educational goals.

The integration of artificial intelligence and adaptive technologies opens exciting long-term possibilities for educational board games that can address individual student needs while preserving the collaborative benefits of group play. AI systems could serve as intelligent tutoring systems integrated into physical games, offer personalized feedback and scaffolding, and even act as advanced game masters that manage complex scenarios beyond what human facilitators can handle.

4.4. Recommendations for Practice and Policy

Current research guides educators, administrators, and policymakers on implementing educational board games. Success depends on understanding that board games are not automatically educational; they become effective learning tools only when carefully designed, thoughtfully facilitated, and systematically integrated with existing educational goals and limitations.

For educators considering the introduction of board games, research emphasizes the importance of starting with clear learning objectives and selecting or creating games that directly target specific skills through well-established mechanical links [1,3]. Teachers should focus on games that need little preparation, fit within typical class times, and align smoothly with the curriculum, rather than serving solely as enrichment activities. Professional development should focus on enhancing facilitation, assessment techniques, and understanding how game mechanics can support specific learning outcomes.

School administrators must understand that the effective implementation of board games involves more than just purchasing and distributing games to teachers. It demands structured professional development, continuous support for troubleshooting and refinement, and assessment methods that reflect the complex learning fostered by these games [3,14]. Administrative backing should allocate time for teacher collaboration, provide resources for iterative game design or

 doi:10.20944/preprints202508.2159.v1

modification, and allow flexibility in assessment and accountability systems to support innovative learning methods.

Policymakers should promote the research and application of educational board games by setting funding priorities that focus on thorough evaluation, teacher professional development, and equity. Policy frameworks should foster innovative assessment methods capable of capturing complex collaborative learning, while still ensuring accountability for educational outcomes. Funding for research should prioritize long-term studies, scalability assessments, and systematic examinations of how board games impact students from diverse backgrounds and with varying learning needs.

5. Conclusions

Educational board games designed to develop advanced secondary student skills have become a promising teaching method that has greatly matured over the last ten years. The field has shifted from initial enthusiasm and theoretical ideas to more refined, evidence-supported frameworks that show real educational advantages, even though some implementation challenges still remain.

Current research makes key contributions by systematically linking specific game mechanics to particular learning objectives, creating practical frameworks that consider real classroom constraints, and providing compelling evidence of educational effectiveness across various subjects and student groups. These advancements establish a strong foundation for further development and broader adoption of educational board game methods.

Unlocking the full potential of educational board games depends on addressing ongoing assessment challenges, professional development requirements, and issues of equity that currently hinder research and practical implementation. The field requires advanced assessment tools, scalable strategies for teacher training, and consistent focus on how board games impact students across diverse backgrounds and learning environments.

The future of educational board games looks promising as emerging technologies open up new hybrid approaches that blend physical and digital learning. Nonetheless, success hinges on preserving core educational values such as authentic collaboration, hands-on interaction, and engaging problem-solving. It is also essential to tackle practical challenges to ensure that innovative educational methods can thrive in real classroom settings.

The evidence suggests that educational board games can significantly support secondary education in developing complex cognitive and social skills, which traditional teaching methods often struggle to foster. Nevertheless, realizing this potential requires ongoing commitment to thorough research, structured professional development, and careful consideration of the practical realities involved in current secondary education settings.

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