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Gamification for Developing 21st-Century Skills in Education: A Review of Current Practices and Impacts

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ABSTRACT

This review aims to examine the role of gamification in fostering collaboration, critical thinking, problem-solving, and digital literacy–the essential 21st-century skills. The review used a structured methodology, while a comprehensive search was conducted across Scopus, ERIC, Google Scholar, and ResearchGate to analyze studies published between January 2010 and August 2025. The findings reveal that when strategically designed, gamification effectively promotes the development of collaboration, critical thinking, problem-solving, and digital literacy skills by embedding game elements into learning activities. Specifically, the findings from the analysis show that collaborative features of gamification tools (e.g., rewards, leaderboards, points) strengthen teamwork, narrative-driven challenges foster critical thinking, and integrated approaches with problem-based learning enhance problem-solving abilities. Furthermore, gamified digital environments significantly enhance students' digital literacy skills. This review concludes that gamification is a powerful and promising pedagogical tool for developing 21st-century skills, but its effectiveness is contingent upon intentional design.

Keywords: gamification, 21st-century skills, collaboration, critical thinking, digital literacy, problem-solving

INTRODUCTION

In today's interconnected and rapidly evolving world, the development of 21st-century skills has become more essential for education systems worldwide (Ağaoğlu & Demir, 2020; Kennedy & Sundberg, 2020). There is no single, explicit definition of 21st Century Skills. Partnership for 21st Century Skills (2009) emphasized that it is a combination of content, skills, and expertise that students must acquire to thrive professionally and personally. Ananiadoui and Claro (2009) further explained that 21st-century skills refer to the specific knowledge, skills, and attributes that 21st-century young people must possess to function successfully as productive employees and active citizens in a society driven by information. The effectiveness of 21st-century skills is built upon a core of knowledge, practical abilities, personal attitudes, ethical values, and moral

standards (Suto & Eccles, 2014). The frameworks ultimately converge on a common set of skills, which are: communication, collaboration, critical thinking, creativity, problem solving, and digital literacy (Ananiadoui & Claro, 2009; Partnership for 21st Century Skills, 2009; Suto & Eccles, 2014; Teo, 2019; Voogt & Roblin, 2010).

The skills, such as critical thinking and problem-solving, while having long been valued, the current economic and social changes demand these competencies to a greater extent than in previous eras (Purwanto et al., 2023; Rosak-Szyrocka & Balsalobre-Lorente, 2025; Rotherham & Willingham, 2010). In addition, skills such as collaboration, creativity, critical thinking, and digital literacy are now seen as essential not only for workforce readiness but also for active global citizenship (Kennedy & Sundberg, 2020; Mahmud & Wong, 2022). This emphasis requires moving beyond traditional content delivery toward pedagogies that deliberately foster these competencies, recognizing the interdependence of skills and knowledge (Ağaoğlu & Demir, 2020; Rotherham & Willingham, 2010). Consequently, educational reforms increasingly call for integrating the teaching and assessment of such skills across curricula (Kennedy & Sundberg, 2020; Rotherham & Willingham, 2010).

One promising approach is gamification–defined as the application of game design elements and principles in non-game educational contexts to enhance engagement, motivation in learning, and promote the development of critical skills (Caponetto et al., 2014; Majuri et al., 2018; Saenboonsong & Poonsawad, 2024; Wulan et al., 2024). Unlike game-based learning, which relies on complete games, gamification incorporates features such as points, badges, leaderboards, progress bars, and narratives into existing learning activities (Manzano-León et al., 2021; Oliveira et al., 2023). Because of its potential to create interactive, motivating, and enjoyable learning experiences for the students, the adoption of gamification tools has grown considerably in education, especially in higher education (Caponetto et al., 2014; Manzano-León et al., 2021; Pum, 2025). Few previous studies provide insights into the gamification's ability to enhance engagement, and motivation is well documented (Caponetto et al., 2014; Manzano-León et al., 202; Pum, 2025); less is known about its specific role in developing key 21st-century skills, specifically, collaboration, critical thinking, problem-solving, and digital literacy skills. Given the urgency of equipping students with these competencies (Kennedy & Sundberg, 2020; Rotherham & Willingham, 2010), a focused synthesis of current evidence is warranted. Most of the previous studies emphasize the general benefits of gamification for learning and performance (Lampropoulos & Sidiropoulos, 2024; Pum, 2025; Poondej & Lerdpornkulrat, 2020; Sailer & Homner, 2020). However, only a few studies directly examine its impact on collaboration, critical thinking, problem-solving, and digital literacy (Angelelli et al., 2023; Firmansyah & Rosmansyah, 2024; Kassenkhan et al., 2025; Koravuna & Surepally, 2020; Rzabayeva et al., 2024). All of these studies separately analyzed the impact of gamification on a specific outcome among collaboration, critical thinking, problem-solving, and digital literacy. For instance, Angelelli et al. (2023) found that game-based intervention helped participants develop critical thinking, creativity, and teamwork by connecting the story's challenges to real-life experiences, while Koravuna and Surepally (2020) found that game-based environments helped advance digital literacy efforts. Though it is unclear how long the effects will last.

This review aims to examine how gamification is being designed and implemented to support the development of collaboration, critical thinking, problem-solving, and digital literacy–the essential 21st-century skills. It synthesizes existing research, evaluates reported outcomes, identifies common design principles, and discusses challenges and limitations.

METHODOLOGY

This document review was conducted to synthesize existing studies on the use of gamification to develop key 21st-century skills, specifically, collaboration, critical thinking, problem-solving, and digital literacy skills. To identify relevant studies, we conducted a search across major academic databases, including Scopus, ERIC, Google Scholar, and ResearchGate. These academic databases cover educational research, social sciences, and interdisciplinary studies. This search follows specific terms and phrases below:

- "21st century skills"
- "Gamification"
- "Gamification education collaboration"
- "Gamification critical thinking"
- "Gamification problem solving"
- "Gamification digital literacy"
- "Educational games 21st century skills"

These terms were used to query the databases, focusing the search on titles, abstracts, and keywords where possible, depending on the specific database functionalities. Linked by Boolean operators (AND, OR), the search strategy was developed using a combination of keywords reflecting the core concepts of the review. The search process aimed to identify studies that directly address the intersection of gamification, education, and targeted 21st-century skills. The search strategies were screened studies based on predefined inclusion and exclusion criteria to ensure their relevance to the review objectives.

Following **Table 1**, the inclusion criteria and exclusion criteria, the selection process involved a two-stage screening. We start by screening titles and abstracts, and then we do a full-text review of potentially relevant studies. The relevant data were systematically extracted using a predefined data extraction template. This template was designed to capture specific information pertinent to the review's objectives. The extracted data points for each study are included in **Table 2**.

The extracted data were then synthesized using a mixed approach. The findings are primarily organized by the target 21st-century skills. Within the discussion for each skill, the synthesis aims to explore the different types of gamification techniques that have been applied with the students, the research methods used to evaluate outcomes, and the specific findings regarding their impact.

Table 1. Inclusion criteria and exclusion criteria

No.	Inclusion criteria
1	Publications must be available in English.
2	Publication types include peer-reviewed journal articles, conference proceedings, book chapters, theses, and dissertations.
3	Studies must focus on the application of gamification or game-based approaches within an educational context.
4	Studies must explicitly measure, discuss, or explore the impact, potential, or relationship of gamification with the development of at least one of the 21st-century skills: collaboration, critical thinking, problem-solving, or digital literacy. Studies that primarily focus on engagement and motivation were included if they also discussed or provided data related to these specific skills.
5	Studies must have been published between January 2010 to August 2025.
	Exclusion criteria
1	Studies not available in English.
2	Publications such as opinion pieces, editorials, or concrete examples of gamification implementation.
3	Studies that solely focused on traditional game-based learning without including the application of gamification principles to non-game contexts.
4	Studies where the educational context or the target skills are not clearly defined or are outside the scope of collaboration, critical thinking, problem-solving, and digital literacy.

Table 2. Summary of data extraction categories for gamification studies

No	Categories	Data points
1	Full citation details	Including author(s), year of publication, title, and source (e.g., journal, conference proceedings, book title, university for dissertations).
2	Educational context	The setting where the study took place (e.g., K-12, higher education, professional training) and the specific subject area or discipline.
3	Participant characteristics	Details about the students or participants involved, such as their educational level and sample size.
4	Type of gamification used	A description of the specific gamification elements, mechanics, or approaches implemented in the study.
5	Targeted 21st-century skill(s)	Identification of the specific skill(s) the gamified intervention aimed to develop or impact, including collaboration, critical thinking, problem-solving, and/or digital literacy.
6	Research methods	The methodological approach and specific methods used to conduct the study and evaluate the impact of gamification (e.g., experimental design, qualitative case study, survey, assessment tools used).
7	Specific findings (impact on skills)	Detailed results and conclusions from the study regarding the effectiveness or observed impact of gamification on the targeted 21st-century skill(s).
8	Reported challenges or limitations	Any difficulties encountered during implementation, limitations of the study design, or challenges related to using gamification were reported by the authors.
9	Reported recommendations	Suggestions for future research, practice, or implementation are provided by the authors.

To ensure the reliability of the data extraction process, data from a subset of studies (approximately 20%) were independently extracted by two reviewers. Any discrepancies were resolved through discussion until consensus was reached, or by consulting a third reviewer if necessary. This structure allows for a detailed analysis of how gamification supports the development of each skill, while highlighting common practices and evaluation methods. It also presents the reported effectiveness and associated challenges drawn from the synthesis of the included studies. Findings are compared and contrasted across studies to identify patterns, variations, and key insights.

FINDING AND DISCUSSION

The sections below discuss the main findings grouped under the themes of gamification for developing collaboration skills, gamification for developing critical thinking skills, gamification for developing problem-solving skills, and gamification for developing digital literacy skills, followed by challenges and considerations in using gamification for skill development.

Gamification for Developing Collaboration Skills

Gamification is not about playing real games; however, it uses the gamification elements such as the process, recognition (e.g., points, badges), and complement (rewards) to engage students and help them to develop their problem-solving and social skills. Combining these two skills develops students' collaborative problem-

solving skills (CPS) (Pei & Harun, 2023). Educational initiatives around the world, such as PISA, prioritize collaborative problem-solving as it is instrumental in building the cognitive, social, and emotional competencies essential for efficiency and innovation in today's economy (Graesser et al. 2018; OECD 2017). Although collaboration lacks a single definition, experts describe it as a mutual, coordinated effort to reach a shared goal, which necessitates sharing goals, resources, and ideas, and is built upon trust, respect, responsibility, and accountability (Détienne et al. 2012). Collaborative skills, which are essential teamwork skills, are being chosen as one of the most important skills in the future workplace (Maraza-Quispe et al., 2024; Walker & Walker, 2019). Intrinsic motivation and collaborative learning, allied to specific learning objectives, were brought into focus (Bovermann & Bastiaens, 2018). According to Maraza-Quispe et al. (2024), upper secondary school students work more collaboratively when integrating the Classcraft gamification platform. The findings further suggested that by implementing this gamification platform, teachers can foster students' internal team management skills and their collaborative learning, while improving students' interdependence and individual and group responsibility among students (Maraza-Quispe et al., 2024). In addition, it was revealed by research that gamification features such as points and leaderboards are considered to play a significant role in influencing students' intrinsic learning motivation and collaborative learning (Bovermann & & Bastiaens, 2019). Furthermore, the 21st-century skills focus on the 4Cs of critical thinking, communication, collaboration, and creativity that can be developed through sandbox video games like Minecraft (Partridge, 2022). The results from Partridge (2022) further showed that the game encourages creativity and critical thinking in a hands-on, interactive learning environment. For the students who use Minecraft in their learning, they demonstrate improved engagement and problem-solving skills. and collaboration with peers. The study also found that when children engage in collaborative Minecraft play, they foster teamwork, communication, and social skills as players exchange ideas and problem-solve in real-time (Partridge, 2022).

Gamification for Developing Critical Thinking Skills

Critical thinking (CT) is the deliberate application of cognitive abilities to solve problems and make decisions effectively (Halpern, 1998). It functions as a structured practice where one analyzes and synthesizes data to continuously refine their thinking (Paul, 1992; Paul & Elder, 2019). Ultimately, the specific skills emphasized in CT are not standardized, but are tailored to the particular demands of the educational setting and discipline (Condon & Kelly-Riley, 2004). Gamification has become one of the popular technologies that is used for developing the user's behavior more effectively with the addition of many types of games (Trinidad et al., 2021). The integration of gamification in education is currently the most useful method for instruction, even though some parts of gamification still need to improve, especially for cognitive learning (Sailer & Homner, 2020). More than that, it was found not only to change behavior but also to encourage physical activity, which is a pathway to understanding the global physical inactivity pandemic (Mazeas et al., 2022). Furthermore, Gamification empowers the user to use their problem-solving skills and allows them to make decisions from critical thinking that is based on their own knowledge to solve the imaginative nuisance from the narrative. Additionally, the researcher shows that increasing the motivation, ability to solve problems, and stimulation by using gamification is more important (Kladchuen & Srisomphan, 2021; Vikingstad & Tjøtta, 2024). Many types of gamifications have relevance in learning that have improved the thinking skills of learners (Martí-Parreño et al., 2019). Moreover, it allows participants to use their own prior knowledge and critical thinking to find the key concept or problem represented by the game's narrative (Angelelli et al., 2023). For example, Correia and Lobo (2024) and Koten and Utama (2023) reported that involving games in education and learning has expanded access to study and also enlarged engagement in learning. As interaction with AI combines with gamification, it enhances adaptation and supports critical thinking skills to a greater extent, and makes the students understand the complex concept (Choustoulakis et al., 2025; Correia & Lobo, 2024; Koravuna & Surepally, 2020; Naatonis et al., 2024).

Gamification for Developing Problem-Solving Skills

Problem-solving and critical thinking are the interconnected skills that cannot be separated. It is an intellectual skill that enables the evaluation and reorganization of one's existing mental framework of knowledge (Hu, 2011; Kocak et al., 2021). Creative problem-solving offers a complete approach to creative problem-solving, demanding that users consider problems from various viewpoints within a supportive setting (Laar et al., 2020). It operates in three steps: Problem Finding (scoping), Idea Finding (using divergent thinking to generate solutions) (Fauziah et al., 2020), and Solution Finding (using convergent thinking to select options). The success of the process depends critically on a risk-tolerant environment fostered by effective leadership (Baran et al., 2021). The scope of gamified problem-solving extends beyond traditional classroom settings to include virtual and collaborative environments. According to a study by Stoeffler et al. (2020) by using a virtual agent in a first-person maze environment, they can effectively measure the cognitive and social aspects of problem-solving. In addition, research conducted by Kladchuen and Srisomphan (2021) has found that gamified learning environments can create a motivating and stimulating context for learners to tackle complex challenges and develop the cognitive and collaborative skills necessary for success in the 21st century. The integration of gamification mechanisms, such as experience points, badges, leaderboards, and challenges with problem-based learning, is significant for motivating students and can further enhance their analytical and problem-solving abilities (Kladchuen & Srisomphan, 2021). Similarly, Poonsawad et al. (2022) developed a problem-based learning model that uses interactive digital storytelling within a gamified environment, which has been shown to significantly promote students' problem-solving skills. In addition, Saenboonsong and Poonsawad (2024) have successfully developed a learning model that combines a gamification environment with cartoon animation media to foster creative problem-solving skills, which made the learning process more engaging and significantly improved students' creative problem-solving abilities. In another study by Machmud et al. (2023) focus was on a theoretical and design framework for a constructivist gamification environment model aimed at improving ill-structured problem-solving in learning sciences. Their framework is built upon psychological, pedagogical, technological, and problem-solving principles, and it emphasizes cognitive aspects such as stimulating cognitive structure and supporting knowledge construction.

Gamification for Developing Digital Literacy Skills

The growing integration in education has been found to significantly impact students' learning and develop their digital literacy skills. Studies have suggested integrating gamification to education to make the learner more accessible and more engaging, with better use and improvement (Koravuna & Surepally, 2020; Rzabayeva et al., 2024). According to Serrano (2019), digital game-based learning helped students develop digital literacy skills more effectively than traditional methods). Gamification transforms routine tasks (such as information evaluation, online safety, and data handling) into dynamic, interactive, and relevant challenge-based activities. This encourages deep engagement, exploration of digital tools, and the development of critical digital competencies (Rzabayeva et al., 2024). Furthermore, it reshapes the experience in the classroom, such as rivalry in the platform of gaming with various players and games related to learning that help to promote digital literacy more effectively (Koravuna & Surepally, 2020). Additionally, gamification is one of the best tools that increases learner cooperation and engagement. It contributes to digital literacy by focusing on the potential of studying in between education and fun, like using prizes, points, and challenging with interesting lessons to get me interaction in a learning environment (Rzabayeva et al., 2024). There are several studies that have shown that gamified learning experiences can significantly improve students' digital literacy. According to Holm (2015), the importance of digital literacy for students has been highlighted by the increasing prevalence of online courses. Holm (2025) found that digital literacy significantly influenced students' performance in online courses, with digitally skilled students achieving higher grades. This study explores how digital literacy is related to academic performance among students enrolled in an online anatomy and physiology course. The results show that some elements of digital literacy play a more significant role in achieving academic success

in the online course. Furthermore, educators can support students in developing skills by using digital game-based learning (Serrano, 2019). Furthermore, the studies show that digital game-based learning, such as collaboration, choice, and feedback, has an impressive positive impact on learner performance (Serrano, 2019).

The important skill in the 21st century is digital literacy, which has become an essential aspect of modern education, allowing students to critically assess, explore, and use it effectively (Alnuaim, 2024). According to McGuinness and Fulton (2019), the case study of over eighty-six higher education institutions on e-tutorials found that accessibility, ease-of-use, design, and duration of the e-tutorials were deemed effective in terms of user engagement. E-tutorials provide students with varied methods for developing essential literacy skills and diverse opportunities to engage with the learning content. Since these tutorials are reusable learning objects, they can be utilized as on-demand resources whenever students feel the need to review specific skills or reinforce material. There are also some effective skills that students can earn from gamification, such as browsing, searching, and filtering data, information, and digital content, interacting through digital technologies, sharing through digital technologies, collaborating through digital technologies, protecting devices, protecting personal data, and privacy (Torres-Toukoumidis & Maeöts, 2019).

Challenges and Considerations in Using Gamification for Skill Development

Challenges were perceived by educators, as serious game designers, to be administrative, design-related, attitudinal, and communicative. When people share different ideas and use creative ways to plan and create games, serious game design and development can be improved. To achieve these goals, trust should be developed between target users, the technical development team, and the educators who use serious games (Dimitriadou et al., 2021). In addition, gamification is effective in developing and assessing soft skills, which play a critical role in the success of individuals, teams, and organizations (Altomari et al., 2023). The application of game features, mainly video game elements, into non-game contexts is known as gamification to make learning more fun and motivating. Using gamification in teaching helps many students who feel disconnected from traditional teaching methods. A possible solution to the decline in learners' motivation and engagement faced by the education system today could be provided through the use of gamification (Alsawaier, 2018). As a result, the appeal of digital games has increased in studies. However, researchers are still working on more studies, particularly on theoretical and methodological advancements (to address this gap, a new approach called Digital Gaming Relationship (DRG) has been introduced that aims to provide a clear framework for understanding how learners interact with digital games) (Sokka et al., 2025). Previous studies defined player types based on their in-game actions and reasons for playing. The results indicate that seeking information related to digital games is an important metagame activity related to other metagame activities. (Kahila et al., 2025). Furthermore, educators view gamification as a powerful tool for boosting student success within modern hybrid learning models. Drawing on the principles of design science research, Thi Binh et al. (2024) developed an outline to design a gamified hybrid course curriculum that includes course content, activities, and assessments based on four gamification elements: achievement, value, benefits, and competition.

CONCLUSION

This review synthesizes how gamification is being utilized to intentionally foster 21st-century skills–collaboration, critical thinking, problem-solving, and digital literacy skills–the skills have been found significant for academic and professional success. Beyond summarizing prior findings, this review contributes new knowledge by systematically linking specific gamification elements (e.g., team-based points, gamified narratives, and problem-based learning integration) to the development of distinct 21st-century skills. For

instance, elements like team-based points, shared challenges, and cooperative platforms were found to foster teamwork, communication, and mutual responsibility. In addition, the analysis shows that gamified narratives and challenges compel learners to apply their prior knowledge and analytical skills to overcome complex obstacles–an element of critical thinking and problem-solving skills. Furthermore, we also found that teachers can foster students' analytical skills and encourage their higher-order thinking by integrating gamification with the problem-based learning (PBL) model. Finally, the review indicated that gamified digital environments inherently support the development of digital literacy by providing students with hands-on experience navigating digital tools, interacting with them, and using various tools and content. By mapping these connections, the review provides educators with actionable insights for strategically designing gamified learning experiences. Additionally, the study highlights that the effectiveness of gamification depends on thoughtful integration, offering a conceptual framework for future research and practical implementation in educational settings.

RECOMMENDATIONS

Based on our comprehensive review, we recommend some strategies to leverage gamification in education in order to develop 21st-century skills, specifically collaboration, critical thinking, problem-solving, and digital literacy. First, teachers/educators should incorporate elements like team-based points, shared challenges, and cooperative platforms, which require students to exercise communication and mutual responsibility to maximize the development of collaboration and teamwork. Second, to foster critical thinking and problem-solving skills, educators should harness the power of gamified narratives and complex challenges because these require learners to apply their prior knowledge and analytical skills to overcome complex obstacles. Third, another effective approach is the integration of gamification with the Problem-Based Learning (PBL) model. This integration will further encourage analytical capabilities and higher-order thinking by embedding complex problem-solving within the game structure. Finally, we recommend that teachers/educators provide students with hands-on experience in navigating, interacting with, and utilizing various digital tools and content, as gamified environments are often digital, their use naturally supports the development of digital literacy. Therefore, the core recommendation is to ensure that the gamified design is intentionally aligned with the specific skill objectives, moving beyond superficial elements to create mechanics that necessitate the use and practice of the target 21st-century skills for successful progression.

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REFERENCES

Ağaoğlu, O., & Demir, M. (2020). The integration of 21st-century skills into education: an evaluation based on an activity example. *Journal of Gifted Education and Creativity*, *7*(3), 105-114. https://bit.ly/4p3xIDu

Alnuaim, A. (2024). The impact and acceptance of gamification by learners in a digital literacy course at the undergraduate level: randomized controlled trial. *JMIR Serious Games, 12*, e52017. https://doi.org/10.2196/52017

Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology*, *35*(1), 56-79. https://doi.org/10.1108/IJILT-02-2017-0009

Altomari, L., Altomari, N., & Iazzolino, G. (2023). Gamification and soft skills assessment in the development of a serious game: Design and feasibility pilot study. *JMIR Serious Games*, *11*(1). e45436. https://doi.org/10.2196/45436

Ananiadoui, K., & Claro, M. (2009). *21st century skills and competences for new millennium learners in OECD countries*. Working Paper. OECD, Paris. https://doi.org/10.1787/19939019

Angelelli, C. V., de Campos Ribeiro, G. M., Severino, M. R., Johnstone, E., Borzenkova, G., & da Silva, D. C. O. (2023). Developing critical thinking skills through gamification. *Thinking Skills and Creativity*, *49*. Article 101354. https://doi.org/10.1016/j.tsc.2023.101354

Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The influence of project-based STEM (PjbL-STEM) applications on the development of 21st-century skills. *Journal of Turkish Science Education, 18*(4), 798–815. https://doi.org/10.36681/tused.2021.104

Bovermann, K. & Bastiaens, T. (2018). Using gamification to foster intrinsic motivation and collaborative learning: a comparative testing. In T. Bastiaens, J. Van Braak, M. Brown, L. Cantoni, M. Castro, R. Christensen, G. Davidson-Shivers, K. DePryck, M. Ebner, M. Fominykh, C. Fulford, S. Hatzipanagos, G. Knezek, K. Kreijns, G. Marks, E. Sointu, E. Korsgaard Sorensen, J. Viteli, J. Voogt, P. Weber, E. Weippl & O. Zawacki-Richter (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology* (pp. 1128-1137). Amsterdam, Netherlands: Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/184321/

Bovermann, K., & Bastiaens, T. (2019). How gamification can foster motivation and collaboration in blended learning: A mixed methods case study. *Journal of Interactive Learning Research, 30*(3), 275-300. https://www.learntechlib.org/p/184766

Caponetto, I., Earp, J., & Ott, M. (2014). Gamification and education: A literature review. *Games Based Learning*, *1*(1), 50-57. https://www.researchgate.net/publication/266515512_Gamification_and_Education_a_Literature_Review

Choustoulakis, E., Athanasopoulou, P., Pollalis, Y., Nikoloudakis, D. (2025). Integrating artificial intelligence with gamification techniques to enhance student motivation and engagement. In: Kavoura, A., Briciu, VA., Briciu, A. (Eds.), *Strategic Innovative Marketing and Tourism*. ICSIMAT 2024. Springer Proceedings in Business and Economics. Springer, Cham. https://doi.org/10.1007/978-3-031-81962-9_58

Condon, W., & Kelly-Riley, D. (2004). Assessing and teaching what we value: The relationship between college-level writing and critical thinking abilities. *Assessing Writing*, *9*(1), 56-75. https://doi.org/10.1016/j.asw.2004.01.003

Correia, A., & Lobo, V. (2024). Enhancing critical thinking in education through AI-driven gamification: The development and impact of the adaptive critical thinking enhancement system (ACTES). In 16th International Conference on Education and New Learning Technologies (pp. 7768-7777). https://doi.org/10.21125/edulearn.2024.1823

Détienne, F., Baker, M., & Burkhardt, J. M. (2012). Perspectives on quality of collaboration in design. *CoDesign*, *8*(4), 197-199. https://doi.org/10.1080/15710882.2012.742350

Dimitriadou, A., Djafarova, N., Turetken, O., Verkuyl, M., & Ferworn, A. (2021). Challenges in serious game design and development: Educators' experiences. *Simulation & Gaming*, *52*(2), 132-152. https://doi.org/10.1177/1046878120944197

Fauziah, M., Marmoah, S., Murwaningsih, T., & Saddhono, K. (2020). Profile of divergent thinking ability of elementary school student in thematic learning. *Elementary Education Online*, *19*(2), 624–640. https://doi.org/10.17051/ilkonline.2020.693109

Firmansyah, F. H., & Rosmansyah, Y. (2024). Exploring collaboration in multiplayer gamification: A systematic literature review. *IEEE Access*, *12*, 149399-149431. https://doi.org/10.1109/ACCESS.2024.3477465

Graesser, A. C., Fiore, S. M., Greiff, S., Andrews-Todd, J., Foltz, P. W., & Hesse, F. W. (2018). Advancing the science of collaborative problem solving. *Psychological Science in the Public Interest*, *19*(2), 59-92. https://doi.org/10.1177/1529100618808244

Halpern, D. (1998). Teaching critical thinking for transfer across domains: Disposition, skills, structure training, and metacognitive monitoring. *American Psychologist, 53*(4), 449-455. https://doi.org/10.1037//0003-066x.53.4.449

Holm, P. (2025). Impact of digital literacy on academic achievement: Evidence from an online anatomy and physiology course. *E-Learning and Digital Media, 22*(2), 139-155. https://doi.org/10.1177/20427530241232489

Hu, C. (2011). Computational thinking: What it might mean and what we might do about it. In Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer Science Education (pp. 223-227). https://doi.org/10.1145/1999747.1999811

Kahila, J., Valtonen, T., López-Pernas, S., Saqr, M., Vartiainen, H., Kahila, S., & Tedre, M. (2025). A typology of metagamers: Identifying player types based on beyond the game activities. *Games and Culture*, *20*(1), 38-58. https://doi.org/10.1177/15554120231187758

Kassenkhan, A. M., Moldagulova, A. N., & Serbin, V. V. (2025). Gamification and artificial intelligence in education: A review of innovative approaches to fostering critical thinking. *IEEE Access*, *13*, 98699 –98728. https://doi.org/10.1109/ACCESS.2025.3576147

Kennedy, T.J., Sundberg, C.W. (2020). 21st Century Skills. In: Akpan, B., Kennedy, T.J. (Eds.), *Science Education in Theory and Practice: An introductory guide to learning theory* (pp. 479-496). Springer Texts in Education. Springer, Cham. https://doi.org/10.1007/978-3-030-43620-9_32

Kladchuen, R., & Srisomphan, J. (2021). The synthesis of a model of problem-based learning with the gamification concept to enhance the problem-solving skills for high vocational certificates. *International Journal of Emerging Technologies in Learning*, *16*(14). 4-21, https://doi.org/10.3991/ijet.v16i14.20439

Kocak, O., Coban, M., Aydin, A., & Cakmak, N. (2021). The mediating role of critical thinking and cooperativity in the 21st century skills of higher education students. *Thinking Skills and Creativity*, *42*. https://doi.org/10.1016/j.tsc.2021.100967

Koravuna, S., & Surepally, U. K. (2020, September). Educational gamification and artificial intelligence for promoting digital literacy. In Proceedings of the 2nd International Conference on Intelligent and Innovative Computing Applications (pp. 1-6). https://doi.org/10.1145/3415088.3415107

Koten, G. J. L., & Utama, C. (2023). Improving critical thinking skills of elementary school students: Project-based learning vs gamification-based group investigation. *Journal for Lesson and Learning Studies*, *6*(2), 311-320. https://doi.org/10.23887/jlls.v6i2.60680

Laar, E. V, Deursen, A. J. A. M. V, Dijk, J. A. G. ., & Haan, J. D. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *SAGE Journal, 10*(1), 1–14. https://doi.org/10.1177/2158244019900176

Lampropoulos, G., & Sidiropoulos, A. (2024). Impact of gamification on students' learning outcomes and academic performance: A longitudinal study comparing online, traditional, and gamified learning. *Education Sciences*, *14*(4), Article 367. https://doi.org/10.3390/educsci14040367

Machmud, M. T., Wattanachai, S., & Samat, C. (2023). Constructivist gamification environment model designing framework to improve ill-structured problem solving in learning sciences. *Educational Technology Research and Development*, *71*(6), 2413–2429. https://doi.org/10.1007/s11423-023-10279-0

Mahmud, M. M., & Wong, S. F. (2022). Digital age: The importance of 21st-century skills among the undergraduates. In *Frontiers in Education*. Frontiers Media SA. https://doi.org/10.3389/feduc.2022.950553

Majuri, J., Koivisto, J., & Hamari, J. (2018). Gamification of education and learning: A review of empirical literature. GamiFIN, 2186, 11-19. http://ceur-ws.org/Vol-2186/paper2.pdf

McGuinness, C., & Fulton, C. (2019). Digital literacy in higher education: A case study of student engagement with e-tutorials using blended learning. *Journal of Information Technology Education: Innovations in Practice, 18*, 1-28. https://doi.org/10.28945/4190

Manzano-León, A., Camacho-Lazarraga, P., Guerrero, M. A., Guerrero-Puerta, L., Aguilar-Parra, J. M., Trigueros, R., & Alias, A. (2021). Between level up and game over: A systematic literature review of gamification in education. *Sustainability*, *13*(4). Article 2247, https://doi.org/10.3390/su13042247

Maraza-Quispe, B., Choquehuanca-Quispe, W., Rosas-Imán, V. H., Quispe-Flores, L. M., Alcázar-Holguin, M. A., Feliciano-Yucra, G., & Martinez-Lopez, A. C. (2024). Impact of gamification on collaborative learning development: A quantitative experimental approach. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, *19*, 51-60. https://doi.org/10.1109/RITA.2024.3368360

Martí-Parreño, J., Galbis-Córdova, A., & Currás-Pérez, R. (2019). Teachers' beliefs about gamification and competencies development: A concept mapping approach. *Innovations in Education and Teaching International*, *58*(1), 84–94. https://doi.org/10.1080/14703297.2019.1683464

Mazeas, A., Duclos, M., Pereira, B., & Chalabaev, A. (2022). Evaluating the effectiveness of gamification on physical activity: systematic review and meta-analysis of randomized controlled trials. *Journal of Medical Internet Research*, *24*(1), 1-19. https://doi.org/10.2196/26779

Naatonis, R. N., Rusijono, R., Jannah, M., & Malahina, E. A. U. (2024). Evaluation of problem based gamification learning (PBGL) model on critical thinking ability with artificial intelligence approach integrated with ChatGPT API: An experimental study. *Qubahan Academic Journal*, *4*(3), 485-520. https://doi.org/10.48161/qaj.v4n3a919

OECD. (2017). *PISA 2015 assessment and analytical framework: Science, reading, mathematic, financial literacy and collaborative problem solving, revised edition*. OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264281820-en

Oliveira, W., Hamari, J., Shi, L., Toda, A. M., Rodrigues, L., Palomino, P. T., & Isotani, S. (2023). Tailored gamification in education: A literature review and future agenda. *Education and Information Technologies*, *28*(1), 373-406. https://doi.org/10.1007/s10639-022-11122-4

Partnership for 21st Century Skills. (2009). *P21 framework definitions*. https://files.eric.ed.gov/fulltext/ED519462.pdf

Partridge, J. (2022). Digital games-based learning: Minecraft in the 21st-century classroom (Doctoral dissertation, University of British Columbia). https://dx.doi.org/10.14288/1.0422940

Paul, R. (1992). Critical thinking: What, why, and how. *New Directions for Community Colleges*, *1992*(77), 3-24. https://doi.org/10.1002/cc.36819927703

Paul, R., & Elder, L. (2019). *The miniature guide to critical thinking concepts and tools*. Rowman & Littlefield. https://www.criticalthinking.org/files/Concepts_Tools.pdf

Pei, C., & Harun, J. (2023). Gamification elements and students' collaborative problem-solving skills: A literature analysis. International *Journal of Academic Research in Business and Social Sciences, 13*(4), 652-661. http://dx.doi.org/10.6007/IJARBSS/v13-i4/16541

Poondej, C., & Lerdpornkulrat, T. (2020). Gamification in e-learning: A Moodle implementation and its effect on student engagement and performance. *Interactive Technology and Smart Education*, *17*(1), 56-66. https://doi.org/10.1108/ITSE-06-2019-0030

Poonsawad, A., Srisomphan, J., & Sanrach, C. (2022). Synthesis of problem-based interactive digital storytelling learning models under gamification environment promotes students' problem-solving skills. *International Journal of Emerging Technologies in Learning*, *17*(5), 103–119. https://www.learntechlib.org/p/222846/

Pum, M. (2025). Examining the predictive role of weekly game-based online quiz performance on academic achievement and engagement. *Asian Journal of Distance Education, 20*(2), 25-38. https://www.asianjde.com/ojs/index.php/AsianJDE/article/view/825

Purwanto, M. B., Hartono, R., & Wahyuni, S. (2023). Essential skills challenges for the 21st century graduates: Creating a generation of high-level competence in the industrial revolution 4.0 era. *Asian Journal of Applied Education*, *2*(3), 279-292. https://doi.org/10.55927/ajae.v2i3.3972

Rosak-Szyrocka, J., & Balsalobre-Lorente, D. (2025). Competencies of the future. In *Enhancing Smart Universities with Emotional Intelligence* (pp. 267-286). Routledge. https://doi.org/10.4324/9781003582267

Rotherham, A. J., & Willingham, D. T. (2010). 21st-century" skills. *American Educator*, *17*(1), 17-20. http://www.aft.org/newspubs/periodicals/ae

Rzabayeva, D., Kassymova, G., & Pratama, H. (2024). The role of gamification in promoting digital literacy: Bridging the gap between fun and learning. Materials of International Scientific-Practical Internet Conference "Challenges of Science", 7, 135-144. http://dx.doi.org/10.31643/2024.20

Saenboonsong, S., & Poonsawad, A. (2024). The development of students' creative problem-solving skills through learning models in a gamification environment together with cartoon animation media. *Journal of Education and Learning*, *13*(2), 138–148. http://www.ccsenet.org/journal/index.php/jel

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review*, *32*(1), 77-112. https://doi.org/10.1007/s10648-019-09498-w

Serrano, K. (2019). The effect of digital game-based learning on student learning: A literature review. *Graduate Research Papers*, 943. https://scholarworks.uni.edu/grp/943

Sokka, M., Ng, K., Kokko, S., & Koski, P. (2025). Introduction of the digital gaming relationship. *Media and Communication*, *13*(1). 1-17. https://doi.org/10.17645/mac.8738

Stoeffler, K., Rosen, Y., Bolsinova, M., & von Davier, A. A. (2020). Gamified performance assessment of collaborative problem-solving skills. *Computers in Human Behavior*, *104*. Article 106036. https://doi.org/10.1016/j.chb.2019.05.033

Suto, I., & Eccles, H. (2014). The Cambridge approach to 21st century skills: Definitions, development and dilemmas for assessment. In the IAEA conference, Singapore (pp. 1-10). file:///C:/Users/admin/Downloads/paper_226dc1e1c2.pdf

Teo, P. (2019). Teaching for the 21st century: A case for dialogic pedagogy. *Learning, Culture and Social Interaction*, *21*, 170-178. https://doi.org/10.1016/j.lcsi.2019.03.009

Thi Binh, A. D., Hoang, T.-H., & Quang, H. T. (2024). Designing effective hybrid course curriculum: a design science approach to gamification and student outcomes validation. *Evaluation Review, 49*(3), 453-486. https://doi.org/10.1177/0193841X241291752

Trinidad, M., Ruiz, M., & Calderon, A. (2021). A bibliometric analysis of gamification research. *IEEE Access*, *9*, 46505-46544. https://doi.org/10.1109/ACCESS.2021.3063986

Torres-Toukoumidis, A., & Maeöts, M. (2019). Implementation of gamification strategies for the enhancement of digital competences. In 13th International Technology, Education and Development Conference (pp. 9510-9518). IATED. https://doi.org/10.21125/inted.2019.2356

Vikingstad, E. D., & Tjøtta, I. (2024). *Gamification as a marketing tool in life-defining decision-making processes* (Master's thesis, BI Norwegian Business School). https://hdl.handle.net/11250/3159863

Voogt, J., & Roblin, N. P. (2010). *21st century skills: Discussion paper*. http://opite.pbworks.com/w/file/fetch/61995295/White%20Paper%20twenty-firstCS_Final_ENG_def2.pdf

Wulan, D. R., Nainggolan, D. M., Hidayat, Y., Rohman, T., & Fiyul, A. Y. (2024). Exploring the benefits and challenges of gamification in enhancing student learning outcomes. *Global International Journal of Innovative Research*, *2*(7), 1657-1674. https://doi.org/10.59613/global.v2i7.238