



CHAPTER- II

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REVIEW OF RELATED LITERATURE

Game Based Learning has been increasingly recognized for its ability to enhance reflective thinking, particularly in subjects like biological science. By integrating game elements, Game Based Learning fosters an environment where reflective thinking flourishes, helping students develop a deeper understanding of biological concepts. Science learning is part of formal education material that must be studied by every student at the High School level. Biological science learning is able to produce quality human resources. Science learning is not limited to the mastery of knowledge, but also as knowledge that is implemented in everyday life (**Astalini et al., 2018**). GBL in Biology education enhances student engagement, motivation, and conceptual understanding. It fosters critical thinking, problem-solving, and collaboration skills, aligning with NEP 2020's emphasis on holistic and enjoyable learning experience.

Carpenter et al., (2021) conducted a research on the effectiveness of incorporating reflection prompts within games. It has been shown to enhance metacognitive awareness, enabling students to assess their problem-solving strategies and adapt their learning approaches accordingly indicating that GBL not only increases student motivation but also facilitates the acquisition of inquiry skills essential for scientific literacy. For instance, a study by **Özlegen** in 2012 demonstrated that students engaged in digital game-based inquiry learning exhibited significant improvements in their ability to formulate hypotheses, design experiments, and analyze data within biological contexts.

Kurniasari and Fauziah (2022) stated in their research paper that basically, there were five high-level thinking skills being logical thinking, critical thinking, reflective thinking, metacognitive thinking, and creative thinking skills. Game Based Learning enhances all these five skills by accelerating active engagement, problem-solving skills, providing immediate feedback and driving collaboration & discussion.

Fauziah (2022) through his study, concluded that GBL scaffolds experiential learning and encourages metacognition. Recent educational researchers are working in the field of high-level thinking skills enhancement among students.

Diana (2022) worked on the GBL learning model and it was also proven to increase learners' interest and motivation in participating in learning activities. Even with the development of its own games that are customized in such a way as to meet the needs, the GBL learning model was able to improve students' literacy skills. The effectiveness of GBL in Biology education is further supported by its capacity to bridge theoretical knowledge with real-world applications. Games designed around biological processes, such as protein synthesis or ecosystem dynamics, provide immersive experiences that contextualize abstract concepts, making them more accessible and relevant to students.

Low and Lim (2023) conducted a similar study that collaborative game-based activities encourage peer interaction and discussion, fostering a community of inquiry where students can articulate their understanding and confront misconceptions.

Stegman (2014) studied on Immune Attack and demonstrated that students who played the game performed better on tests related to cellular immunology and exhibited increased confidence in interpreting complex scientific diagrams compared to peers who played non-educational games. Research indicates that integrating both educational and commercially developed video games into educational settings can enhance students' comprehension and retention of biological knowledge. Educational games such as Immune Attack, Immune Defense, Tyto Online, and Genomics Digital Lab are specifically designed to teach complex biological concepts through interactive gameplay.

Drogaris (2023) conducted a similar research on effectiveness of commercially developed games like Spore, Plague Inc., Cell to Singularity, and Niche on incorporating biological and evolutionary concepts into their gameplay and found that those actions potentially fostered interest and understanding in Biological Science. While those games were not explicitly designed for educational purposes, but their engaging content positively complemented formal Biology education by stimulating curiosity and providing contextual experiences related to biological processes.

Game Based Learning (GBL) has emerged as a revolutionary educational approach in recent years, seamlessly integrating educational content with interactive and engaging game elements. This innovative method taps into children's natural inclination towards play and exploration, making it particularly effective for young learners. Game Based Learning has demonstrated significant potential in enhancing reflective thinking skills among students, particularly in Biology education.

Dewi (2021) conducted a study to examine the role of reflection prompts within game-based science learning environments. Objective of the study was to examine the effectiveness of educational board games in enhancing students' reflective thinking abilities during nutrition education. Participants of the research were Junior high school students in Indonesia. Research followed a Quasi-experimental study with pre-test and post-test assessments. Intervention was the implementation of a specially designed educational board game focused on nutrition topics. As assessment tool, Reflective Thinking Scale was used to evaluating stages such as reaction, elaboration, and contemplation. The findings indicated that both in-game and instructor-guided reflection prompts effectively facilitated students' reflective thinking, thereby enhancing their understanding of scientific concepts. But post-intervention results indicated significant improvements in students' reflective thinking abilities across all assessed stages and the interactive nature of the board game facilitated increased student participation and engagement with nutritional concepts. Furthermore, students demonstrated improved critical analysis skills, applying learned concepts to real-life scenarios. These insights suggest that incorporating structured reflection opportunities within GBL can foster deeper cognitive engagement and promote the development of reflective thinking skills in Biology students.

Mutlu (2020) through his study, demonstrated that 7th-grade students using reflective worksheets in inquiry-based learning environments showed significant improvement in scientific process skills, including hypothesis formulation and data interpretation.

Yore and Treagust (2006) in their research found that science journal writing positively affects students' comprehension, interest, and ability to critically reflect on scientific concepts.

Tammu (2022) reported that Biology education students using reflective journals in a genetics course improved in concept understanding, attitudes, and learning experiences, indicating enhanced self-regulated learning strategies.

Bonus et, al., (2024) introduced BioScientist, a digital game-based inquiry learning program, into the Biology curriculum for eighth-grade students. The research found that students who engaged with BioScientist exhibited improved inquiry skills, which are closely linked to reflective thinking, as they involved processes like hypothesis formulation, data analysis, and drawing conclusions.

Phan (2024) conducted a mixed-methods study to investigate the impact of a simulation game called "The Ward" on nursing students' reflective thinking skills. Over seven weeks, students participated in weekly gameplay sessions, followed by reflective activities. The results indicated a significant increase in reflective thinking scores, with students reporting enhanced self-awareness, improved decision-making skills, and greater motivation. The study concluded that simulation games can be a valuable tool in nursing education to foster reflective practice. The objective of the research was to investigate the effect of a simulation game called "The Ward" on the reflective thinking skills of senior nursing students. A convergent parallel mixed-methods design was employed, integrating both quantitative and qualitative data to provide a comprehensive understanding of the simulation game's impact. A convenience sample of 23 senior nursing students from Düzce University, Türkiye, who were enrolled in their final semester and had taken the General Practice Course. Participants engaged in the simulation game "The Ward" once a week for seven weeks. The game was designed to simulate real-life clinical scenarios requiring critical thinking and decision-making. Reflective Thinking Scale (RTS) administered before and after the intervention to quantitatively assess changes in reflective thinking skills and Structured interview form was used to collect qualitative data through focus group interviews, exploring students' experiences and perceptions during the simulation. There was a statistically significant increase in reflective thinking scores post-intervention with a Pre-test Mean Score of 39.70 ± 5.15 while Post-test Mean Score of 67.39 ± 8.13 and Statistically Significant at $p < 0.05$. This indicated that participation in the simulation game markedly enhanced students' reflective thinking abilities.

Analysis of focus group interviews revealed that there was enhanced Self-Awareness as Students became more cognizant of their knowledge gaps and areas needing improvement along with Improved Decision-Making as engagement in realistic scenarios fostered better clinical judgment and critical thinking. Furthermore, collaborative Learning was enhanced as the simulation promoted teamwork and communication among peers. Finally, motivation of students was increased as experiential learning through simulation heightened students' interest and engagement in the subject matter.

Board games are chosen as an innovative medium to improve students' reflective thinking skills. Board games have many advantages as learning media. Board games have also proven successful in improving student skills. Many studies have shown the successful use of board game in training students' thinking skills. With all its advantages, the board game also improves students' reflective thinking skills. Recent research has demonstrated the effectiveness of card games in enhancing the learning experience of physiology students. One notable example is the "**CARBGAME**" (CARd & Board GAMES in Medical Education), an innovative gamification tool developed to promote active and team-based learning in physiology education.

Surapaneni (2024) investigated the effectiveness of CARBGAME. The study involving 150 Phase-I MBBS students, the CARBGAME focused on cardiovascular physiology. Students participated in a board game where they answered questions to advance on the game board, culminating in solving a case-based question. The results showed a significant improvement in knowledge, with pre-test scores increasing from 6.5 to 15.3 ($p < 0.0001$). Feedback from students was overwhelmingly positive, highlighting aspects such as fun, relevance, motivation, and collaborative learning. The study concluded that CARBGAME effectively enhanced student engagement and learning outcomes in physiology education

Erdemir, N., and Uyanik, G. K. (2024) developed a digital game called "*BioScientist*". The research aimed to design and implement the game, to be integrated into the Biology curriculum for 8th-grade students. The primary objectives were to assess whether the game could improve students' inquiry skills and motivation toward Biology. The study involved 257 eighth graders, divided into experimental and control groups.

The experimental group used BioScientist both at home and in the classroom, while the control group continued with traditional teaching methods. Results indicated that students using BioScientist showed a significant improvement in inquiry skills compared to the control group. However, there was no notable difference in motivation toward Biology between the two groups. The BioScientist digital game effectively supported the development of inquiry skills in Biology education. Its integration into the curriculum offered a promising approach to enhance students' scientific thinking and engagement with biological concepts.

Surapaneni et. al., (2024) designed "*Aquilibrium: The Battle to Balance*," a narrative card and board game aimed to teach acid-base regulation to first-year medical students. In a study with 120 participants, students played the game in small groups, engaging with a captivating storyline that integrated physiological concepts. The results indicated a significant improvement in academic performance, with pre-test scores rising from 7.57 to 16.14 ($p < 0.0001$). Students also reported increased confidence in understanding acid-base regulation and provided highly positive feedback on the game's effectiveness as a learning tool.

Lantzouni et. al., (2024) conducted a study which shows that using games in Biology education promises to enhance engagement, promote active learning, and deepen understanding, contributing to narrowing the gap in biological literacy.

Recent research underscores the pivotal role of reflective thinking skills in enhancing academic performance among school students. Studies indicate that students with strong reflective thinking abilities—such as questioning, reasoning, and evaluating—demonstrate improved problem-solving skills, particularly in science and mathematics. For instance, research involving eighth-grade students revealed that reflective thinking skills positively correlate with the ability to solve both routine and non-routine science problems (**ICASE, 2023**). Similarly, a study on fourth-grade primary school students found a positive relationship between reflective thinking skills and academic success in mathematics (**IOJET, 2023**). Furthermore, interventions like metacognitive and argument-driven learning environments have been shown to stimulate and support students' reflective thinking skills, suggesting that structured reflective practices can enhance cognitive engagement and learning outcomes (**IJRES, 2023**).

These findings highlight the importance of integrating reflective thinking strategies into educational curricula to foster critical thinking and academic excellence. Recent research has explored the enhancement of reflective thinking skills in school students through Game Based Learning (GBL).

Shaheen, Ali, and Fotaris (2023) developed a Reflective Game Design (RGD) framework by integrating reflective learning principles into digital games. Through participatory design and prototype evaluations, the study found that games incorporating reflective prompts and feedback mechanisms effectively engaged learners and promoted deeper understanding of content. The research involved a user survey with 101 participants and semi-structured interviews with 15 individuals, revealing that 86.5% accepted the idea of reflective game design. Embedding reflective elements, such as feedback loops and decision-making consequences, within game mechanics encourages learners to think critically about their actions and outcomes. Such design considerations are vital for promoting sustained reflective thinking during gameplay. The study concluded that incorporating reflective elements such as heads-up displays, performance comparison charts, and social collaboration can promote deeper learning and critical thinking.

Cloude et al., (2021) examined the use of Game Based Learning analytics to support adolescents' reflection. The study analyzed 120 adolescents' written reflections during gameplay and found that both the quantity and quality of reflections were positively correlated with learning outcomes and problem-solving abilities. The researchers emphasized the importance of aligning reflection prompts with specific learning goals to maximize reflection, learning, and performance.

Kember et al., (2014) developed a Reflective Thinking Questionnaire (RTQ). This questionnaire categorized reflection into four levels: habitual action, understanding, reflection, and critical reflection. It has been utilized in various studies to measure students' reflective thinking abilities.

Can, B., and Yıldırım, C. G., (2014) published a paper titled " The Instrument for Determining the Levels of Reflective Thinking Among Elementary School Students". This instrument was designed to assess the reflective thinking levels of elementary school students. The study aimed to develop a reliable and valid measurement tool to evaluate students' reflective thinking skills. The authors Bilge Can and Cennet Gizem Yıldırım conducted validity and reliability analyses to ensure the instrument's effectiveness in educational settings.

Yang, X., and Liu, Y., (2021) investigated and found that incorporating reflection prompts within games or guided instructor-led reflections can facilitate students' understanding and retention of scientific concepts. These reflective practices encourage students to connect gameplay experiences with underlying biological principles, enhancing their overall learning experience. Reflective thinking, a critical component of meaningful learning, is also supported through GBL. This study on financial literacy games demonstrated that the combination of strategic game mechanics and direct reflection prompts significantly increased students' perceived utility value of the game, underscoring the importance of instructional design in serious games. Structured debriefing sessions following gameplay serve as a platform for learners to consolidate knowledge, reflect on their experiences, and receive feedback. In clinical education, debriefing has been identified as the most crucial phase of simulation-based learning, where students analyze their performance and strategize for improvement. The integration of reflective prompts and structured debriefing sessions in game-based learning environments has been shown to significantly enhance learners' critical thinking, self-awareness, and ability to apply knowledge in real-world contexts. These strategies encourage students to engage deeply with the content, analyze their experiences, and develop meaningful connections between gameplay and practical applications. In the realm of project sustainability management, debriefing sessions are routinely conducted to discuss and analyze game-based learning experiences. These sessions promote social learning and knowledge co-production, enhancing the overall educational impact of the games. The deliberate incorporation of reflection mechanisms within educational games, coupled with structured debriefing sessions, constitutes a powerful pedagogical approach that enriches the learning experience and fosters the development of essential cognitive and metacognitive skills.

Incorporating reflective prompts within games and conducting structured debriefing sessions post-gameplay have been shown to deepen learners' understanding, enhance critical thinking, and foster self-awareness. Recent studies across various educational contexts support the efficacy of these strategies. Reflective prompts embedded within educational games encourage learners to critically analyze their experiences and relate them to real-world applications. These findings align with existing research on the effectiveness of educational card games. For instance, a study published in the *Journal of MicroBiology & Biology Education* reported that students who participated in an educational card game showed a mean gain score of 12.675, significantly higher than the 9.225 gain observed in the control group employing traditional teaching methods. The statistical analysis confirmed the superiority of the game-based approach in reinforcing learning outcomes.

Solanki and Mathew (2022) carried out a survey study and found that a majority of Indian students view Game Based Learning favorably, associating it with increased motivation and improved understanding, particularly in subjects like STEM and history. These kind of research indicates a positive perception of GBL among Indian students.

Setiawan and Phillipson (2019) conducted a meta-analysis of studies from 2010 to 2017, concluding that game-based science learning significantly improves students' academic achievement.

Yien et al. (2011) examined a similar study which demonstrated that integrating educational card games into science instruction positively enhanced students' learning performance and attitudes toward the subject.

Pratama and Setyaningrum (2018) carried out a research which indicated that Game Based Learning positively affects both cognitive and affective aspects of students, leading to improved mathematics learning outcomes.

Baßeng and Budke (2025) investigated the impact of peer coaching on students' reflective processes during geography lessons that utilized digital games. The findings revealed that combining reflection diaries with peer coaching during debriefing sessions significantly increased the depth of students' reflections.

Specifically, students were able to formulate more precise and critical statements when comparing game scenarios to real-world contexts and in their self-reflections. Working in pairs and receiving targeted questions from coaches were identified as key factors in promoting deeper reflection. Recent research underscores the effectiveness of peer coaching and collaborative reflection in enhancing learners' reflective thinking, particularly within educational settings that incorporate digital tools and game-based learning.

Johnson, S. R., Finlon, K. J., Kobak, R., and Izard, C. E., (2016) performed a study which highlighted the role of collaborative reflection in broadening preservice teachers' perspectives. Engaging in structured discussions with peers allowed these teachers to exchange diverse insights, challenge existing assumptions, and consider alternative approaches to teaching. This collaborative process not only enhanced their reflective thinking but also contributed to a more nuanced understanding of teaching practices.

Farrell, L., Cuncic, C., Hartford, W., Hatala, R., and Ajjawi, R., (2024) executed a pilot program integrating multisource feedback (MSF) with peer coaching among physicians demonstrated notable improvements in self-directed learning. Participants reported enhanced abilities in identifying learning strategies, accessing resources, and evaluating learning outcomes. The combination of MSF and peer coaching facilitated deeper reflection on clinical practices and promoted ongoing professional development. This pilot program involved physicians completing a 360-degree assessment of their practices, followed by peer coaching sessions. The peer coaches were trained using the R2C2 feedback model to support coaching skills development. The study utilized a mixed-methods evaluation, including pre- and post-surveys of readiness for self-directed learning, a post-evaluation survey of participant satisfaction, and semi-structured participant interviews. Results indicated significant improvements in participants' readiness for self-directed learning, including enhanced abilities to identify learning strategies, access resources, and evaluate learning outcomes. Participants reported feeling empowered to reflect on their practices, affirm their strengths, and identify opportunities for ongoing professional development. The combination of MSF and peer coaching emerged as key elements in enabling reflective practice and facilitating self-directed professional development.

Ferreira, A., Araújo, B., Alves, J., Príncipe, F., Mota, L., Novais, S., van den Berg, J., van der Vleuten, C., and Kusurkar, R., (2023) developed the PEERFEED-E Clinico 1.0 model in nursing education that emphasized the role of peer feedback in cultivating metacognitive competencies. Both students and educators acknowledged improvements in teamwork, critical thinking, communication, and self-regulation. Quantitative data indicated high levels of agreement on the importance of peer feedback in enhancing these skills. A study on peer group reflection meetings during medical students' clinical rotations found that such sessions increased self-awareness and coping abilities. Students benefited from sharing experiences, gaining alternative perspectives, and developing self-efficacy in managing clinical challenges. The presence of a skilled coach was pivotal in creating a safe environment conducive to meaningful reflection.

Kim, H., and Kim, S. (2024) developed a debriefing strategy emphasizing collaborative reflection in virtual simulation-based nursing education. The randomized controlled trial demonstrated significant improvements in students' knowledge, problem-solving skills, self-confidence in clinical decision-making, reflective thinking, and satisfaction. The findings underscore the effectiveness of structured debriefing sessions in enhancing critical thinking and problem-solving abilities.

Yildirim, B., and Ozkan, S., (2024) conducted a mixed-method study which investigated the impact of simulation games on nursing students' reflective thinking skills. Over a seven-week period, students exhibited significant improvements in reflective thinking, particularly in understanding and reflection levels. Qualitative data revealed that the simulation games fostered teamwork, broadened perspectives, and enhanced decision-making skills, highlighting the role of game-based activities in promoting critical reflection.

García-Holgado, A., García-Peñalvo, F. J., and Rodríguez-Conde, M. J., (2020) carried out a study to explore the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) activities embedded with reflection and cooperation in primary education. The findings suggested that such approaches develop higher levels of thinking and learning among students, promoting critical reflection and collaborative problem-solving skills.

Huang, Y. M., and Chiu, P. S., (2022) examined the impact of Socratic reflection prompts delivered through a video-based learning system on elementary students' critical thinking skills. The study found that such prompts significantly enhanced students' critical thinking abilities, emphasizing the importance of incorporating reflective elements within educational technologies.

Villareale, J., Biemer, C. F., Seif El-Nasr, M., and Zhu, J., (2020) published a paper. This paper analyzes how reflection is supported in educational programming games. The authors identify that current approaches often prioritize accuracy over the individual learning process and suggest the need for game designs that facilitate player reflection through embedded mechanics, thereby enhancing critical thinking and problem-solving skills.

In India, the "Science is Fun" outreach program exemplifies this approach by conducting workshops that involve hands-on experiments, such as building periscopes and digital microscopes. These activities have been successful in stimulating curiosity and fostering a deeper understanding of scientific concepts among students, especially in under-resourced schools. Additionally, the Activity-Based Learning (ABL) methodology, implemented in various Indian schools, utilizes games and interactive activities to make learning more engaging and effective.

Internationally, research supports the efficacy of Game Based Learning (GBL) in Biology education. A study in the Philippines validated the use of game-based activities, such as "ECO-WARRIOR" and "ECO-CHALLENGE," in teaching ecosystems to Grade 7 students. The findings indicated that these games met educational standards and significantly improved students' academic performance and engagement. Similarly, in Hungary, the implementation of the digital game "BioScientist" in eighth-grade Biology classes enhanced students' inquiry skills, including hypothesis formulation and data interpretation.

Further studies have explored the use of educational card games to reinforce biological concepts. Research conducted at Bulacan State University demonstrated that students who engaged with Biology-themed card games exhibited higher gains in understanding compared to those taught through traditional methods.

Moreover, tabletop games integrated into natural science courses in Taiwan significantly improved students' learning motivation and effectiveness, highlighting the versatility of game formats in education.

These findings underscore the importance of incorporating games into Biology teaching for middle-stage students. Games not only make learning more interactive and enjoyable but also promote critical thinking, problem-solving, and collaboration. As educational paradigms shift towards more student-centered approaches, Game Based Learning emerges as a valuable tool in enhancing Biology education both in India and globally.

However, the implementation of GBL is not without challenges. **Yaman, H., Sousa, C., Neves, P. P., and Luz, F. (2023)** conducted a systematic review which identified several barriers, including limited resources, lack of training, and resistance to change among educators, which can hinder the effective integration of GBL in universities. Despite these challenges, the growing body of research underscores GBL's potential to transform traditional educational paradigms and promote active, student-centered learning.

Despite the exciting momentum behind game-based learning (GBL) for boosting reflective thinking, key gaps still hold us back from seeing its full educational value. For one, although games are hailed as “reflection machines”, only a handful of frameworks actually weave structured, real-time reflection prompts or scaffolds into gameplay; typically, reflection only happens after the game ends. We also lack solid guidance on when, how, and in what format to present these reflective prompts, leaving game designers without a clear roadmap. On top of that, we haven’t invested enough in exploring social reflection, like peer discourse and collaborative reflection, even though working together often deepens understanding. Finally, there’s a serious shortage of longer-term studies that track how in-game reflection affects students’ metacognitive growth over time and even fewer comparisons between GBL and traditional reflective teaching. In short, there’s a pressing need for research that designs, implements, and tests in-game reflection scaffolds that actively support students while they’re playing not just afterward.