Kashihara, A. et al. (Eds.) (2024). Proceedings of the 32nd International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

Learning Effectiveness and Reflections on AI Literacy in Junior High School Students with Game-Based Learning and Problem-Based Learning

Shih-Hua HUANG[a] & Ting-Chia HSU[*]
Department of Technology Application and Human Resource Development, National Taiwan Normal University, Taiwan
*ckhsu@ntnu.edu.tw

Abstract: This research attempts to cultivate the AI literacy of junior high school students and aims to evaluate the learning effectiveness of integrating game-based learning with problem-based learning to improve their AI literacy. Using a self-developed board game on Naive Bayes Classifier and Generative AI applications as teaching material, students engage in a problem-based learning approach through group collaboration. The results of the research show a significant improvement in students' AI literacy, particularly in their understanding of AI, and a significant increase in their behavioral intentions and engagement. The results confirm the effectiveness of this pedagogical approach for promoting AI literacy at the high school level.

Keywords: Game-based learning, Problem-based learning, AI literacy

1. Introduction

The rapid development of artificial intelligence (AI) is systematically transforming industries and everyday life. Taiwan's education system needs to proactively prepare students by fostering AI literacy and skills to meet future workplace challenges and maintain global competitiveness. In recent years, the wave of AI has surged, with a variety of AI applications and services, such as ChatGPT, image recognition, and smart home appliances, being launched. These technologies have rapidly entered and transformed our lives, not only improving our quality of life and convenience but also driving significant changes across various industries. The development of AI is bringing about widespread changes, and in the future, regardless of the industry, AI is bound to systematically alter existing industries and jobs, becoming a core force in industrial transformation. Microsoft CEO Satya Nadella stated that AI will significantly enhance the productivity of 8 billion people globally and improve the lives of billions (Van Dis et al., 2023).

In terms of technology education, Taiwan's 108 Course Guidelines have incorporated the field of technology from 2019, reflecting an awareness of future trends. The goal is to equip students with basic technological literacy, enabling them to apply these knowledge and skills in their daily lives. The course in information technology focuses on developing students' fundamental IT skills, especially as they face the rapid evolution of technology. The importance of AI literacy has become particularly evident with the rapid advancement of AI technologies. Students not only need to possess basic IT skills but must also understand how to critically use and apply these technologies. AI literacy, which encompasses the ability to understand, operate, and evaluate AI, has become an indispensable competency in the 21st century.

Mastering AI literacy can help students stay competitive in the future job market, where AI applications are becoming increasingly common in industries ranging from automated manufacturing to smart healthcare, and even in the legal and education sectors. Therefore,

students with AI literacy will be better equipped to face workplace challenges and seize new opportunities brought about by AI. Additionally, AI literacy helps students better understand the usage, application, creation, limitations and ethical challenges of AI. Blind reliance on AI can lead to misuse or privacy violations. Therefore, cultivating students' critical thinking skills to properly use AI and identify its potential risks is crucial for the sustainable development of society especially in Taiwan, a major hub of technology, it is crucial to prepare early to maintain our global competitiveness. Therefore, it is essential to help everyone understand how AI operates, its limitations, and its potential social impact in the future. Education should play a key role in this, cultivating the skills needed for K-12 students to handle AI in their future careers (Touretzky et al., 2019).

Through AI literacy education, students will have the ability to participate in technological innovation. If students acquire the ability to create AI applications, they will not only be able to solve real-world problems but also contribute to societal progress by creating more intelligent technologies that meet human needs. Thus, AI literacy is not just an extension of technological education but a core competency required to face the challenges of the future globalized and digitized era. Strengthening AI literacy within the educational system will equip students with the adaptability and judgment needed to navigate the transformations of the future, allowing them to thrive in a world full of opportunities and challenges.

Given the aforementioned background and motivation, it is clear that AI literacy is an indispensable skill in a future dominated by technology. Students not only need to know how to use AI but also need to develop critical thinking and problem-solving abilities. However, current research on junior high school students learning AI literacy through game-based learning and problem-based leaning is relatively lacking. Therefore, this research starts from the perspective of junior high school students' daily lives and designs a series of instructional activities. These activities include guiding students to watch relevant educational videos and using a board game to deepen their understanding of how AI classifiers work and how to properly use generative AI. By combining problem-based leaning, students are encouraged to find answers from problems, further enhancing their AI literacy. The research employs an experimental design to explore the following questions:

1. Does game-based learning combined with problem-based leaning improve students' learning effectiveness in AI literacy?
2. Does game-based learning combined with problem-based leaning improve students' attitudes in AI literacy?
3. Does game-based learning combined with problem-based leaning improve students' attitudes?

2. Literature Review

2.1 Game-based learning

Game-based learning is regarded as a teaching method that can stimulate active student participation, cultivate skills, and promote positive values. It creates an enjoyable learning environment, enhances students' motivation, and improves their comprehension (Jääskä et al., 2021). In game-based learning, content and gameplay help students acquire knowledge and develop skills, while game activities involving problem-solving tasks and challenges can provide students with a sense of accomplishment (Kay & Kwak, 2018). Game-based learning is characterized by five key features: (1) action over explanation, (2) creation of personal motivation and satisfaction, (3) adaptability to various learning styles and skills, (4) reinforcement of knowledge mastery, and (5) provision of an interactive and decision-making environment. These features enable the integration of game-based learning into various educational settings and levels. Sun et al. (2022) have shown that game-based learning offers many benefits for teachers' instruction, particularly by capturing students' interest and facilitating their learning of foundational knowledge. However, the negative impact of game-

based learning includes challenges for novice students or those lacking experience in game-based learning to apply prior knowledge to the game, leading to low motivation and engagement. This highlights the need for teachers to incorporate scaffolding into game-based learning, helping students connect game content with academic knowledge.

Games can liberate individuals from contextual constraints. During gameplay, individuals focus on tasks rather than thinking about the underlying motivations driving their behavior. As a result, we often become immersed in games, experiencing a sense of liberation from the surrounding environment. Darmayanti (2023) suggests that the effectiveness of game-based learning is influenced by five key dimensions: (1) the learning environment, (2) learners, (3) instructional methods, (4) prior knowledge, and (5) teachers. The gamified content directly impacts learning effectiveness and learner behavior. Since gamification is typically not used to replace instruction but to enhance it, effective instructional content is a prerequisite for successful gamification. In summary, game-based learning is a teaching method that can enhance student engagement and learning effectiveness. Through features such as concrete actions, personal motivation, and an interactive environment, it promotes students' mastery of knowledge. However, for inexperienced students, game-based learning may present challenges, necessitating teachers to use scaffolding to help students integrate game content with academic knowledge. The success of gamified learning depends on effective instructional design and adaptability to learners' needs, thereby maximizing its educational benefits.

2.2 Problem-based learning

Problem-Based Learning (PBL) is a student-centered learning approach that guides students through activities such as problem analysis, goal setting, data collection, idea synthesis, and reflective problem-solving experiences, often in a group learning context. It primarily cultivates critical thinking, enhances logical reasoning, problem-solving, and cooperative learning skills (Liu & Pásztor, 2022). PBL is highly directive and can enhance self-regulation skills through creative learning and higher-order thinking (Morris & Rohs, 2021). According to Barrows (1996), PBL is distinguished from other teaching strategies by six fundamental characteristics: (1) placing students at the center of the learning process to promote autonomous learning, (2) organizing students into small groups to facilitate collaboration and joint problem-solving, (3) positioning the teacher as a facilitator or guide who poses relevant questions to steer students' cognitive processes, (4) introducing real-world problems at the outset of learning to identify knowledge gaps and stimulate inquiry, (5) using problems as a guide to achieve learning objectives and master the subject matter, and (6) encouraging self-directed learning as a means of acquiring new knowledge.

Many educators currently use PBL to address the shortcomings of traditional teaching methods (Bulut Ates & Aktamis, 2024). PBL is widely recognized as an effective method for fostering creativity in students, allowing them to engage in critical thinking, explore multiple creative approaches, and collaborate to solve problems. The integration of creativity, PBL, and gamification into an innovative educational approach can enhance student motivation and engagement. When students face complex problems that require innovative solutions, PBL can promote the development of creativity to address real-world challenges and situations (Anggraeni et al., 2023). PBL has demonstrated positive learning effectiveness for students in subjects such as mathematics, science, and STEM. It is an excellent method for designing interdisciplinary instruction because it combines problem-solving with hands-on learning, helping students achieve a deeper understanding of practical skills.

2.3 AI literacy

Artificial Intelligence (AI) has a profound impact on our daily lives and work environments. To address the challenges and seize the opportunities brought by AI, AI literacy can be defined as a set of abilities that enable individuals to critically evaluate AI technologies, communicate

and collaborate effectively with AI, and use AI as a tool in online platforms, at home, and in the workplace (Long & Magerko, 2020). Additionally, Ng et al. (2021) highlight the risks posed by AI applications such as deep fakes, emphasizing that to navigate the opportunities and challenges of AI, citizens need a fundamental understanding of AI and the ability to use and evaluate AI systems. These skills are commonly referred to as AI literacy.

Ng et al. (2021) divide AI literacy into four dimensions: understanding, applying, evaluating, and creating, as well as ethics, covering a comprehensive range of skills from foundational knowledge to practical application and ethical considerations. They argue that learners should grasp basic concepts and functions of AI and be able to apply AI knowledge in their daily lives. Furthermore, learners should critically evaluate AI technologies and develop the ability to follow ethical principles when using AI. This perspective offers a broad view of AI literacy, encompassing the entire process from knowledge comprehension to ethical application.

Long & Magerko (2020), on the other hand, categorize AI literacy into four aspects: identifying AI, understanding how it works, learning tools, and lifelong learning, with a focus on the technical and learning processes. They believe that learners should be able to identify which platforms or applications use AI technologies and understand how AI operates. In addition, learners should be capable of using various AI tools to learn and complete tasks while maintaining a lifelong learning attitude. This perspective provides more detailed and practical guidance, explaining how to engage in AI learning and practice through specific tools and platforms.

Combining the viewpoints of these scholars provides educators with a comprehensive and detailed AI literacy framework, better supporting students in their learning and development within the AI field.

3. Method

3.1 Course and Instructional Design

This research utilizes a self-developed board game as instructional material to teach students through a series of lessons on Naive Bayes Classifier, AI literacy, and related topics. The game incorporates problem-based learning, encouraging students in the same group to collaborate and use electronic devices to search for information. The theoretical course content includes artificial intelligence, machine learning, and AI literacy. The Course employs self-created materials combined with online tools such as Quick Draw and ChatGPT, as well as the self-developed board game, allowing junior high school students, even those with no prior experience with generative AI, to start learning and experiencing from scratch.

3.1.1 Board Game Instructional Material Design

The board games developed for this study are based on the themes of the Naive Bayes classifier and AI literacy. They are team-based competitive board games. The Naive Bayes classifier board game focuses on machine learning as the learning objective, allowing students to play the role of a computer, performing feature classification just like a computer would. The AI literacy board game is designed to teach students how to craft precise prompts for generative AI, so that the AI can provide the desired answers. Through these two customized board games, students' AI literacy is improved

The Naive Bayes Classifier board game aims to help students understand how computers learn and classify images based on similar features. During the game, students take on the role of the computer and classify animal cards based on their features. They actively search for relevant feature knowledge using electronic devices and discuss their findings with team members. After making the classifications, students calculate the final

prediction probability using Bayes' theorem. The team with the highest probability after competing against their opponents is declared the winner.

The AI literacy board game helps students understand that different prompts given to generative AI yield different results. Therefore, crafting accurate prompts to obtain desired answers is crucial. In this game, students play the role of generative AI users who must decode a black-and-white, blurry image by providing accurate prompts. The more precise the prompts, the higher the confidence value achieved. Students then present their decoded images to their opponents, with a score awarded if the confidence value exceeds a specified threshold. The team with the highest score wins.

3.1.2 Board Game Integrated with Problem-Based Learning Course Design

The Course for this research is conducted over one day, totaling 6.5 hours. The design targets students from grades 7 to 9, with the learning goal being to develop students' AI literacy. Students are expected to learn foundational concepts in artificial intelligence, machine learning, and AI literacy through a board game integrated with problem-based learning.

In the theoretical part of the course, students watch videos and presentations created by the researcher, accompanied by learning sheets. During the board game sessions, students frequently ask ChatGPT for answers and discuss with their team members to engage in higher-level thinking. In the reflection part of the course, teachers guide students through discussions about their experiences during the game, reinforcing their understanding of the knowledge points covered.

The course is divided into three parts: (1) Theoretical Instruction: Students learn about artificial intelligence, machine learning, and AI literacy. (2) Board Game with Problem-Based Learning: Students experience board games focused on Naive Bayes Classifier and AI literacy, collaborating in pairs and using ChatGPT to inquire about game-related knowledge. (3) Guided Reflection: Teachers use questioning techniques to prompt students to reflect on their experiences during the game, encouraging discussions and sharing among team members to deepen their understanding of the knowledge covered in the game.

3.2 Research Participants

The participants of this Research are junior high school students from grades 7 to 9. The experiment was conducted at a junior high school in a one-day camp held in August 2024. A total of 31 students participated in this Research. Prior to the experiment, none of the students had previously participated in a Course that combined game-based learning with problem-based learning for AI literacy.

3.3 Research Tools

This research primarily employs experimental methods and questionnaire surveys. The research measurement tools include pre- and post-tests and questionnaires. The learning achievement pre- and post-tests use custom-developed AI literacy assessment tests, while the questionnaires cover scales for AI literacy and learning behavior attitudes.

3.3.1 AI Literacy Learning Effectiveness Test

In this research, the AI literacy learning effectiveness test was administered before the course began and after it ended. The test was designed by the researchers based on the content of the Naive Bayes Classifier and AI literacy Course, and was finalized after expert review. The test consists of two types of questions: multiple-choice and matching. There are 24 multiple-

choice questions and 1 matching question, totaling 25 questions and a maximum score of 100 points.

3.3.2 AI Literacy Learning Behavior Scale

To measure learners' AI literacy, this research employed the AI literacy scale developed by Ng et al. (2022), Long & Magerko (2020), and Wang et al. (2022). The scale consists of five dimensions with a total of 22 items, and it uses a five-point Likert scale for assessment, ranging from 1 (strongly disagree) to 5 (strongly agree).
The five dimensions of the scale are as follows: (1). Application of AI: This dimension assesses whether individuals use AI in their daily lives, with a Cronbach's α = 0.93. (2). Understanding of AI: This dimension evaluates the ability to understand the definition and advantages/disadvantages of AI, with a Cronbach's α = 0.87. (3). Recognition of AI: This dimension determines whether individuals can identify if an application they use is based on AI, with a Cronbach's α = 0.77. (4). Creation of AI: This dimension measures whether individuals can design and develop new AI applications, with a Cronbach's α = 0.92. (5). AI Ethics: This dimension assesses the understanding of the ethical implications of AI applications, with a Cronbach's α = 0.75

3.3.3 Learning Behavior Attitude Scale

For measuring AI learning behavior, this research uses the AI learning behavior scale developed by Ng et al. (2023). The scale consists of three dimensions with a total of 11 items and utilizes a five-point Likert scale for assessment, ranging from 1 (strongly disagree) to 5 (strongly agree).
The three dimensions of the scale are as follows: (1). Intrinsic Motivation: This dimension assesses whether individuals find learning about AI interesting and meaningful, with a Cronbach's α = 0.77. (2). Behavioral Intention: This dimension evaluates whether individuals intend to learn about AI in the future, with a Cronbach's α = 0.84. (3). Behavioral Engagement: This dimension measures whether individuals are actively engaged in AI learning activities, with a Cronbach's α = 0.83.

3.4 Teaching Experiment Design

This research employs a single-group experimental design to explore the effectiveness of combining game-based learning with problem-based learning in enhancing AI literacy among junior high school students. Prior to the course, students complete the AI Literacy learning effectiveness Test, AI Literacy Attitude Scale, and Learning Behavior Attitude Scale to assess their initial abilities. Following this, students learn through viewing videos on relevant concepts and then engage in board games focused on Naive Bayes Classifier and AI literacy. During the games, students use ChatGPT to resolve questions and collaborate with team members. After the games, a guided reflection activity is conducted where the teacher poses questions to help students review their learning experiences. Finally, post-tests are administered to evaluate the students' AI literacy improvement, and the AI Literacy Attitude Scale and Learning Behavior Attitude Scale are re-administered to assess changes.

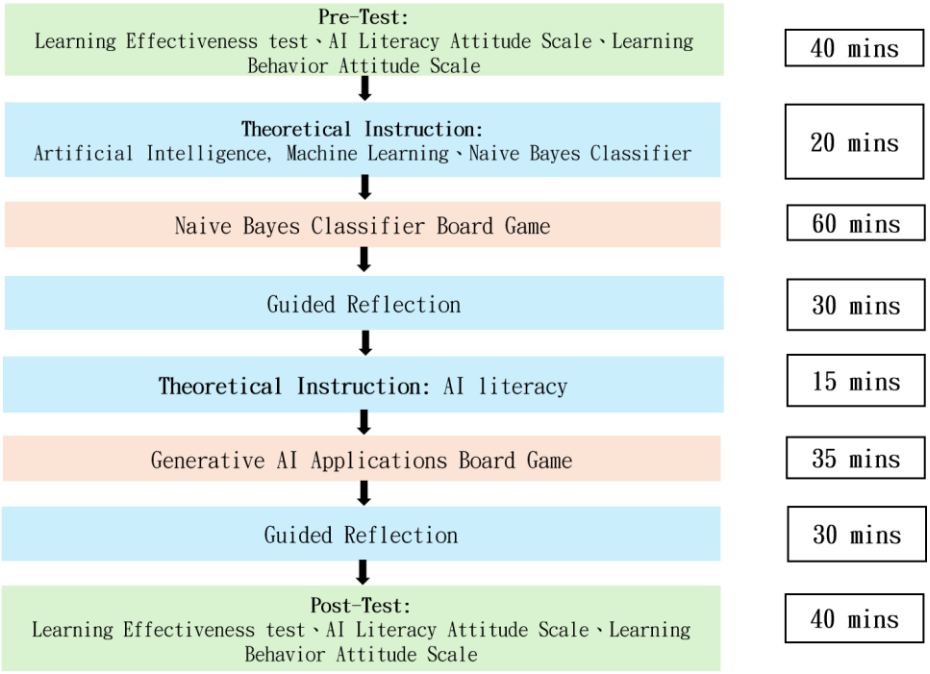

Figure 1. The flowchart of the experiment in this research.

4. Results and Discussion

This research aims to explore whether combining game-based learning with problem-based learning can enhance students' AI literacy learning effectiveness, AI literacy itself, and learning behavior attitudes. To this end, a board game focused on Naive Bayes Classifier and AI literacy was developed. The knowledge component is learned through students independently watching videos and completing worksheets. When encountering problems during the board game, students seek solutions using ChatGPT. The research participants included 31 students from grades 7 to 9 (junior high school) who took part in this experiment.

4.1 Pre- and Post-Test on AI Literacy Learning effectiveness

The learning effectiveness test consists of 25 questions, with a total score of 100 points, including one matching question worth 4 points and 24 multiple-choice questions worth 96 points. The Kolmogorov-Smirnov test was used to check for normality, and the results showed that both the pre-test and post-test passed the normality test ($p > .05$). Therefore, a paired sample t-test was conducted to compare the pre-test and post-test results.

There was a significant difference in the learning effectiveness between the pre-test and post-test ($p < .001$). The post-test scores (M = 60.42, SD = 14.80) were significantly higher than the pre-test scores (M = 33.45, SD = 17.52). The results indicate that the combination of game-based learning with problem-based learning adopted in this research significantly improved students' AI literacy concepts, demonstrating that they acquired knowledge related to AI literacy. The statistical results are shown in Table 1.

Table 1. *Statistical Table for Students' AI Literacy Learning effectiveness Pre- and Post-Tests*

	N	M	SD	t
Pre-Test	31	33.45	17.52	-9.64***
Post-Test	31	60.42	14.80	

***$p<.001$

4.2 Pre- and Post-Test Evaluation of the AI Literacy Attitude Scale

The AI literacy attitude scale consists of 22 questions, divided into five dimensions which are “Application of AI” (i.e., 6 items), “Understanding AI” (i.e., 6 items), “Recognizing AI” (i.e., 3 items), “AI Ethics” (i.e., 3 items), and “Creating AI” (i.e., 4 items). The Kolmogorov-Smirnov

test was used to check for normality. The results showed that only the pre-test for AI literacy attitude passed the normality test (p > .05), while the others did not. Therefore, a non-parametric analysis was conducted to compare the pre- and post-test results for AI literacy attitude.

The AI literacy attitude scale showed a significant difference between the pre-test and post-test results (p = .001<.01). The post-test scores (M = 3.95, SD = 0.93) were significantly higher than the pre-test scores (M = 3.62, SD = 0.69). The results indicate that the combination of game-based learning with problem-based learning adopted in this research significantly improved students' attitude in AI literacy. The statistical results are shown in Table 2.

Table 2. *Statistical Table for Students' AI Literacy Attitude Scale Pre- and Post-Tests*

	N	M	SD	MR	Z
Pre-Test	31	3.62	0.69	15.61	-3.20**
Post-Test	31	3.95	0.93	10.42	

**p<.01

4.3 Pre- and Post-Test Evaluation of Learning Behavior Attitude Scale

The learning behavior attitude scale consists of 11 questions, divided into three dimensions which are Intrinsic Motivation (i.e., 4 items), Behavioral Intentions (i.e., 3 items), and Behavioral Engagement (i.e., 4 items). The Kolmogorov-Smirnov test was used to check for normality. The results showed that only the pre-test Learning Behavior Attitude passed the normality test (p > .05), while the others did not. Therefore, a non-parametric analysis was conducted to compare the pre- and post-test results for the Learning Behavior Attitude.

There was a significant difference between the pre-test and post-test for the overall Learning Behavior Attitude Scale (p = .002< .01). The post-test scores (M = 3.89, SD = 0.99) were significantly higher than the pre-test scores (M = 3.56, SD = 0.91). The results indicate that the combination of game-based learning with problem-based learning adopted in this research significantly improved students' learning behavior attitudes. The statistical results are shown in Table 3.

Table 3. *Statistical Table for Students' Learning Behavior Attitude Scale Pre- and Post-Tests*

	N	M	SD	MR	Z
Pre-Test	31	3.56	0.91	15.10	-3.08**
Post-Test	31	3.89	0.99	10.17	

**p<.01

5. Conclusion

This research explored how combining game-based learning with problem-based learning can enhance junior high school students' AI literacy and learning attitudes. The results indicate that game-based learning effectively promotes student engagement and motivation, particularly when integrated with problem-based learning, which further enhances students' critical thinking and problem-solving skills. This finding aligns with Plass, Homer, & Kinzer (2015), who demonstrated that game-based learning environments are widely recognized for increasing student engagement and perceived achievement. In such games, content is often designed around problem-solving tasks and challenges, requiring students to reflect on the underlying knowledge and build more generalized and applicable knowledge structures. This suggests that game-based learning combined with problem-based learning holds potential for developing students' technological literacy.

The board game used in this research translated abstract concepts of AI literacy into concrete learning experiences, allowing students to gain a deeper understanding of Naive Bayes Classifier and generative AI principles through interactive play. The game enhanced

students' practical perception and operational skills related to AI literacy by involving them in collaborative problem-solving, as the problem-solving stages and strategies reflect their knowledge and skill acquisition during gameplay (Yavuz, Yasemin, & Arslan, 2017). In the game, implicit knowledge is embedded, enabling students to gradually build their knowledge and abilities (Rowe et al., 2021).

Additionally, students' attitudes toward AI literacy and their learning behaviors showed significant improvement after the experiment, particularly in the dimension of understanding AI literacy, indicating that students gained a clearer understanding of AI-related definitions, advantages, and disadvantages. This demonstrates that combining game-based learning with problem-based learning effectively enhances students' understanding of AI and critical thinking skills, which are particularly important in the context of rapid technological advancement.

In summary, this research confirms the effectiveness of integrating game-based learning with problem-based learning in AI literacy education. Future educational designs should consider incorporating gamification elements with problem-based learning and emphasize the role of teacher support in the classroom to maximize learning effectiveness. This approach will further enhance students' knowledge, skills, and attitudes in the field of AI, laying a solid foundation for their future learning and life.

Acknowledgement

This study is partially supported by the National Science and Technology Council under contract number NSTC 111-2410-H-003-168-MY3 and NSTC 113-2628-H-003-002 in Taiwan.

References

Anggraeni, D. M., Prahani, B. K., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem based learning research in fostering critical thinking skills. Thinking Skills and Creativity, 49, 101334.

Ates, C. B., & Aktamis, H. (2024). Investigating the effects of creative educational modules blended with Cognitive Research Trust (CoRT) techniques and Problem Based Learning (PBL) on students' scientific creativity skills and perceptions in science education. Thinking Skills and Creativity, 51, 101471.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. New directions for teaching and learning, 1996(68), 3-12.

Darmayanti, R. (2023). BAPER AKU: Development of a Commendable Moral-Based Permutation Board Game for High School Students. Delta-Phi: Jurnal Pendidikan Matematika, 1(1).

Dondio, P., Gusev, V., & Rocha, M. (2023). Do games reduce maths anxiety? A meta-analysis. Computers & Education, 194, 104650.

Jääskä, E., Aaltonen, K., & Kujala, J. (2021). Game-based learning in project sustainability management education. Sustainability (Switzerland), 13(15).

Kay, R., & Kwak, J. Y. (2018). Comparing types of mathematics apps used in primary school classrooms: an exploratory analysis. Journal of Computers in Education, 5, 349-371.

Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. Thinking Skills and Creativity, 45, 101069.

Morris, T. H., & Rohs, M. (2021). Digitization bolstering self-directed learning for information literate adults–A systematic review. Computers and Education Open, 2, 100048.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. Educational psychologist, 50(4), 258-283.

Sun, L., Ruokamo, H., Kangas, M., & Siklander, P. (2022). Effects of Collaborative Digital Gameplay on Students' Three Dimensions of Engagement in Mathematics. International Journal of Game-Based Learning (IJGBL), 12(1), 1-16.

Touretzky, D., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K-12: What should every child know about AI?. In Proceedings of the AAAI conference on artificial intelligence (Vol. 33, No. 01, pp. 9795-9799).

Van Dis, E. A., Bollen, J., Zuidema, W., Van Rooij, R., & Bockting, C. L. (2023). ChatGPT: five priorities for research. Nature, 614(7947), 224-226

Yavuz, G., Yasemin, D., & Arslan, Ç. (2017). Elementary School Students Perception Levels of Problem Solving Skills. Universal Journal of Educational Research, 5(11), 1896-1901.