



The Effect of Game-Based Learning Media with Problem-Based Learning Model on Self-Regulated Learning and Critical Thinking Skills

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ABSTRACT

This study aims to determine the effectiveness of using Game-Based Learning media combined with the Problem-Based Learning model in science learning to improve self-regulated learning and critical thinking skills. This quantitative study used a quasi-experimental design with a randomized pretest-posttest control group design. It involved 74 seventh-grade students at SMP Negeri 1 Sampit, Indonesia, divided into control and experimental classes through cluster random sampling. Data were collected using test and non-test methods and analyzed with MANOVA in SPSS 28. The results showed that GBL media with the PBL model was effectively used in science learning to improve self-regulated learning and critical thinking skills with a significance of 0.003 and an effect size of 0.158 which is included in the large category. The limitations of this study are the relatively small number of samples, only one comparison group, and the short duration of the study. The implications of research with small samples and the lack of comparison groups are that it produces results that are less representative and difficult to generalize. Further research can be conducted using a wider and more diverse sample, comparing the effectiveness of GBL media with other media, and increasing the research period. This study's originality is its use of a combination of research methods, GBL media, and PBL models in science learning. The study's main value is contributing to learning innovation and the application of methods relevant to the challenges of modern education.

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1. INTRODUCTION

Critical thinking skills are vital for students in the 21st century because the world is full of complex challenges, rapid changes, and ever-growing information. However, various studies and observations in the field reveal that students' critical thinking skills in Indonesia remain relatively low (Hidayati et al., 2021; Jumaisyaroh et al., 2015). Most students in Indonesia face difficulties in developing critical thinking skills and the learning process is still teacher-focused (Saputra et al., 2019), so it does not encourage critical thinking skills (Saputri et al., 2018).

In addition to critical thinking, most students in Indonesia also have difficulty developing self-regulated learning. Students tend to be passive during learning, only receive information and instructions from teachers without asking many questions about the material being taught, often feel hesitant in solving problems, do not prepare before the learning process, and only study the lesson material before the exam. In addition, students also tend to wait for other friends when asked to appear and work on questions in front of the class, only rely on teaching materials in the form of the worksheet which has limited material, and are less interested in studying the material because it is not equipped with pictures or illustrations (Febriyanti & Imami, 2021; Nurhidayanti et al., 2022; Pramana & Dewi, 2014; Sutarno & Mukhidin, 2013).

The findings from observations and interviews conducted at SMP Negeri 1 Sampit showed that learning activities still tend to be passive, only a small number of students take the initiative to ask and answer questions from teachers, and students can answer "what" questions, but have difficulty explaining "why" and "how" questions, students more often construct knowledge based on information obtained from textbooks and teacher explanations, students do not have the initiative to explore information from various learning sources, teachers rarely use learning media and more often use textbooks and worksheets, students show a lack of self-confidence in their ability to complete tasks, students' dependence on other students when doing assignments, and students' inability to manage their study time independently.

Training critical thinking skills and students' self-regulated learning cannot be separated from the learning activities carried out. Optimal results are achieved through learning models that involve active students, such as Problem-Based Learning (PBL). Research shows that PBL is an effective method for enhancing critical thinking skills (Liu & Pásztor, 2022; Safitri et al., 2024) because the PBL model helps students develop essential problem-solving skills (Amin et al., 2020; Sartika et al., 2023). In addition, PBL helps students find science concepts independently and improve their understanding (Sari et al., 2020). Students engaged in the PBL model demonstrate superior critical thinking, metacognitive, and collaboration skills than those who use teacher-centered learning methods (Sungur & Tekkaya, 2006). The PBL model motivates students through problem-solving and group discussions, which encourage the enhancement of critical thinking skills. Unlike traditional learning that relies on direct questions from teachers, PBL provides greater opportunities for students to think critically (Dabbagh, 2019; Fadilla et al., 2021; Wahyu et al., 2017). Active discussions in PBL allow students to propose answers, understand friends' views, and design and evaluate solutions, which ultimately increases their independence in solving problems (Alsaleh, 2020; Safitri et al., 2024).

Game-Based Learning (GBL) can help develop self-regulated learning and critical thinking skills. GBL can encourage students to maintain focus in learning (Lampropoulos, 2023; Setyawan et al., 2019), create a more interesting learning environment (Bakhsh et al., 2022; Liu et al., 2020), can arouse interest and encourage independent learning (Capuno, 2023;

Mayer, 2018), provide a sense of achievement for players or students (Qian & Clark, 2016), and can improve overall performance in critical thinking (Chen & Wu, 2021; Mao et al., 2022). Based on the description, this study aimed to explore the effect of integrating GBL media with the PBL model on improving self-regulated learning and critical thinking skills in science learning.

2. METODE

2.1 Research Design

This study employed a quantitative quasi-experimental design, specifically the randomized pretest-posttest control group design, to examine the effects of different learning media on students' self-regulated learning and critical thinking skills. Table 1 illustrates the experimental design implemented in this research.

Table 1. Randomized Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experiment	O ₁	Xa	O ₂
Control	O ₃	Xb	O ₄

Xa = PBL model + Game-Based Learning media
 Xb = PBL model + PowerPoint media
 O₁, O₃ = self-regulated learning and critical thinking skills before learning
 O₂, O₄ = self-regulated learning and critical thinking skills after learning

The intervention was conducted over five meetings during April and May 2024, focusing on the topic of Earth's Structure in the Science subject. The research population comprised all seventh-grade students at SMP Negeri 1 Sampit, Central Kalimantan, Indonesia, during the even semester of the 2023/2024 academic year. A total of 74 students were selected through cluster random sampling, assigned equally into the experimental and control groups based on class similarity in initial abilities.

2.2 Data Collection Technique

Data were gathered through both non-test and test instruments. The non-test instrument consisted of a self-regulated learning questionnaire with 22 items, validated both theoretically and empirically. The questionnaire covered six indicators: (1) taking initiative in learning, (2) planning learning strategies, (3) implementing learning strategies, (4) utilizing existing abilities, (5) evaluating learning outcomes, and (6) appreciating learning outcomes. These indicators and sample items are detailed in Table 2.

Table 2. Statement Items in the Self-Regulated Learning Questionnaire

Self-Regulated Learning Indicators	Statement Items in the Self-Regulated Learning Questionnaire
Taking initiative in learning	Try to do the practice questions yourself even if you are not asked Complete assigned tasks even without teacher supervision Try to find out the answer to the question given by the teacher even without the teacher paying attention Work straight away without waiting for other friends to work first

Self-Regulated Learning Indicators	Statement Items in the Self-Regulated Learning Questionnaire
Planning learning strategies	Have studied the lesson material that will be taught before the lesson begins
Implementing learning strategies	Note down things you don't understand to ask the teacher Doing all learning activities, not just listening to the teacher's explanation Participate in discussions during learning. Ask questions when you don't understand the lesson material. Learn by seeking knowledge independently Repeat the task until you understand it
Utilizing existing abilities	Do the exam/test on your own, without help from others Take the exam/test seriously Share responsibility for completing all group assignments given by the teacher Never late in completing various tasks Happy to present the results of the group discussions Not having difficulty learning the material even without direct guidance from the teacher Try hard to answer questions asked by the teacher according to your abilities
Evaluating learning outcomes	Rushing to find out the correct answer when answering the teacher's question with the wrong answer Trying to find out the correct answer after completing the exam/test
Appreciating learning outcomes	It's nice when teachers appreciate the results of your work. No regret trying on your own without the help of friends when the exam/test results are less than satisfactory

Meanwhile, the test technique is carried out by using questions to measure students' critical thinking skills. The questions consist of 14 questions that have been declared theoretically and empirically valid. The indicators of critical thinking skills include explaining, analyzing, concluding, evaluating, and making decisions. The indicators of critical thinking skills are shown in table 3.

Table 3. Question Items in Critical Thinking Skills Questions

Critical Thinking Skills Indicators	Question Items in Critical Thinking Skills Questions
Explaining	Explain the process of convection currents. Explain the differences between two seismic waves. Explain the function of one part of a volcano correctly.
Analyzing	Analyze the properties of the earth's inner core based on temperature and substance content. Estimating the name of the plate that stretches across Indonesia. Predicting the temperature of volcanic lava based on its color.
Concluding	Compare the earth's crust and the earth's core.

Critical Thinking Skills Indicators	Question Items in Critical Thinking Skills Questions
Evaluating Making decisions	Compare the properties between continental crust and oceanic crust.
	Providing logical conclusions to the evidence of a fossil.
	Estimating areas with potential for building nuclear power plants.
	Conclude a region that does not have volcanoes.
	Exploring the potential of volcanoes as a renewable energy source.
	Describe the evacuation efforts chosen.
	Making decisions to save important items during a volcanic eruption.

2.3 Data Analysis Technique

The analysis used is the MANOVA test using SPSS 28. There are nine basic assumptions that must be met in the MANOVA test, namely: 1) the type of data is in the form of intervals or ratios; 2) the independent variable consists of two or more categories; 3) there is independence between groups; 4) sufficient sample size; 5) there are no outliers, either univariate or multivariate; 6) observations of the dependent variable are distributed normally multivariate in each group; 7) a linear relationship exists between each pair of dependent variables and each group of independent variables; 8) there is no multicollinearity; and 9) there is the homogeneity of the variance-covariance matrix (Shanthi, 2019).

3. RESULT AND DISCUSSION

3.1. Result

The effectiveness of Game-Based Learning (GBL) media in science learning is evaluated by comparing the self-regulated learning and critical thinking skills of students in the experimental group using GBL media with those in the control group using PPT media. Self-regulated learning is determined using a questionnaire, while critical thinking skills are determined using questions. Both the self-regulated learning questionnaire and the critical thinking skills test questions are tested twice, namely before and after learning. The two values obtained are then calculated for the difference (gain) to determine the difference between before and after learning. The results of the descriptive analysis comparing the gain in self-regulated learning and critical thinking skills of students in both groups are shown in table 4.

Table 14. Descriptive Statistical Analysis of Self-Regulated Learning and Critical Thinking Skills

Information	Gain Self-Regulated Learning		Gain Critical Thinking Skills	
	Control Group	Experiment Group	Control Group	Experiment Group
Mean	3.46	6.30	10.57	22.38
Highest score	41	36	50	57
Lowest score	-18	-23	-29	-7
Standard deviation	13.751	11.482	18.361	16.845
Variance	189.089	131.826	337.141	283.742

Table 4 illustrates a difference in the average self-regulated learning scores between the control and experimental groups, namely 3.46 and 6.30. The average critical thinking skills scores also showed a difference, with the control group scoring 10.57 and the experimental group scoring 22.38. These results indicate that the self-regulated learning and critical thinking skills of students in the experimental group using GBL media are superior to students in the control group using PPT media.

Before conducting hypothesis testing using MANOVA, it is necessary to conduct an assumption test as a prerequisite. After nine assumptions have been tested and all meet the requirements, the analysis is continued with a hypothesis test using MANOVA. This test aims to evaluate the effectiveness of GBL media on independent learning and critical thinking skills. The multivariate approach assesses the simultaneous impact of these two variables on the control and experimental groups. The results of the MANOVA test are shown in table 5.

Table 5. Multivariate Test on MANOVA

	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Group	Hotelling's Trace	.188	6.210b	2.000	66.000	.003	.158

Multivariate results were conducted by reading data in the group for Hotelling's trace test, which obtained a sig value = 0.003, meaning that there were simultaneous differences in self-regulated learning and critical thinking skills between the control and the experimental group. How much influence the use of GBL media has on self-regulated learning and critical thinking skills can be known based on the effect size by looking at the partial eta square in Hotelling's trace test. The partial eta squared criteria are provided in table 6 (Ellis, 2010).

Table 6. Cohen's Effect Size Benchmark

Test	Relevant Effect Size	Effect Size Classification		
		Small	Medium	Large
ANOVA	f	0.10	0.25	0.40
	η^2	0.01	0.06	0.14
Multiple regression	R ²	0.02	0.13	0.26
	f ²	0.02	0.15	0.35

By comparing partial eta square = 0.158 and the classification criteria in table 6, it can be determined that the use of GBL media simultaneously can enhance students' self-regulated learning and critical thinking skills within a large effect category.

3.2 Disucssion

The activities conducted during the learning process demonstrate that students possess the ability to regulate their own learning. This aligns with research indicating that game-based assessment in the classroom can stimulate interest and promote independent learning (Capuno, 2023). One benefit of game-based learning is that it encourages players to be more independent in the learning process, as they take responsibility for monitoring and regulating their cognitive processes while playing games (Mayer, 2018; Susilana et al., 2022). Although

practically students are arranged in groups, they can manage their progress through individual games (Hartt et al., 2020). Games can also capture students' interest and boost their commitment, as the activities are enjoyable and help them stay positive even though they fail (Taub et al., 2017).

Independent learners tend to be more effective in utilizing in-game resources and are more careful in decision-making. Although highly independent learners are not always superior in solving challenges, they tend to experience significant learning improvements due to their involvement in the game (Sabourin et al., 2012). This behavior is seen during the investigation stage where learners tend to take the initiative and can determine various strategies to complete the game. When learners work together to complete game missions, the free exchange of ideas in a PBL environment allows learners to collaborate, share insights, and learn from each other, resulting in improved solutions and narratives (Blythe & Sweet, 2008). The PBL model provides space for learners to express ideas to each other in solving problems. The ability to explain can be built through group discussion activities, providing feedback based on questions given by the teacher, and presenting the results of group discussions (Indriani et al., 2019). Through activities that encourage exploration, provide interaction, and provide opportunities for play through diverse media and role-play in challenging problem-based scenarios, GBL media offers enjoyable learning experiences for students, enhancing and supporting the learning process (Liu et al., 2014).

Learning through games can motivate students to actively seek the best strategies for solving problems (Hosseini et al., 2019). Students not only passively receive information but also actively participate in analyzing and evaluating situations. Students can interact with their friends and discuss strategies related to the game, which can indirectly improve their coordination and social skills. Problem-based curricula applied in the context of games can help students connect subject matter with their personal experiences.

Digital media plays a crucial role in developing students' analytical skills (Johan et al., 2022). This finding is in line with previous studies showing that GBL media significantly improves critical thinking skills (Agustiani et al., 2024; Chen & Wu, 2021; Safitri & Jumadi, 2024). GBL media has an impact on increasing critical thinking skills due to the thoroughness of analysis and the role of active participation in discussions (Wahyu et al., 2017). Games can inspire students to integrate knowledge from various fields and use it in decision-making. Challenging interactive games help students think strategically, analyze situations, and make wise decisions (Katual et al., 2023). GBL elements, such as competition, rewards, and challenges, successfully increase the level of critical thinking by encouraging active involvement and focus on learning objectives (Cicchino, 2015; Molin, 2017). Traditional games presented through mobile applications encourage learners to be more active in sharing knowledge, stimulate critical thinking, and produce creative responses (Chang & Yeh, 2021). Problems in GBL that are complex and have incomplete information allow learners to try various strategies to solve them. The feedback given assists learners in assessing their use of information and decision-making, ultimately improving their critical thinking skills (Hwang & Chang, 2020; Wu et al., 2012).

Game-based learning approaches play a role in developing problem-solving skills by offering a variety of ways to find solutions. These abilities are assessed through challenges in the game, and students are also encouraged to work together to complete the challenges (Adipat et al., 2021). Comprehensive content in mobile learning can stimulate students to compile, apply, analyze, synthesize, and evaluate information obtained from the application more effectively (Rasyid et al., 2020). GBL can replicate real-world problems with limited

information in a safe environment, enabling students to explore various strategies. Through feedback, students assess the information provided, make decisions, and enhance their critical thinking skills over time ([Mao et al., 2022](#)). GBL media learning provides real, individual experiences for students. This is in line with Dale's theory which states that the best way to learn is through direct experience, not just watching or listening to others demonstrate or tell something.

4. CONCLUSION

Based on the research results, GBL media can be used as a science learning media for the Earth Structure material in middle schools. The use of GBL media in science learning can improve students' understanding of complex concepts and improve the development of a more innovative and interesting curriculum. In addition, GBL media can also be used as a reference in developing similar learning media with different materials and dependent variables. GBL media can be used to study abstract, complex, interdisciplinary, and contextual materials. GBL media is not suitable for use on concrete materials and requires direct observation in the laboratory or environment.

The results of this study have limitations, namely the number of samples is only 74 students, which is considered relatively small to represent the results of the study in general. In addition, the design of this study only compares two groups, namely the group using GBL media and the group using PowerPoint media. Although the results of the study show that GBL media applied in learning using the PBL model provides positive results in learning, further research is required to assess the effectiveness of GBL media in relation to other learning media. Further research can be conducted using a wider and more diverse sample so that the results can be more generalized. Developing and testing GBL media for various subjects, materials, and levels of education also needs to be done. In addition, the learning cycle needs to be carried out with a longer duration to better understand the influence of GBL media in science learning.

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