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EFFECTIVENESS OF HOTS-BASED GAME-BASED LEARNING ON CRITICAL THINKING ABILITIES AND NUMERATION LITERACY OF GRADE IV STUDENTS OF LAMBUNU ELEMENTARY SCHOOL, PARIGI MOUTONG DISTRICT

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ABSTRACT

This study aims to analyze the effectiveness of game-based learning based on Higher Order Thinking Skills (HOTS) on the critical thinking skills and numeracy literacy of fourth- grade students of SDN Lambunu , Parigi Moutong Regency . The method used is quantitative with a quasi-experimental nonequivalent control group design . The sample consisted of 56 students divided into experimental and control groups . The research instrument was a validated critical thinking and numeracy literacy test . Data were analyzed using the Shapiro-Wilk normality test , Levene's homogeneity test, independent sample t-test, and N-gain score. The results showed that there were significant differences between the two groups in critical thinking skills ($t = 9.847$; $p = 0.000$) and numeracy literacy ($t = 10.213$; $p = 0.000$). The posttest mean of the experimental group was higher than the control group in both variables . The N-gain value of the experimental group was 0.61 and 0.60, which are in the medium category , while the control group only achieved the low category . It was concluded that HOTS - based game-based learning has been proven to be effective in improving critical thinking skills and numeracy literacy of elementary school students and is worthy of wider implementation in educational contexts . base in remote areas .

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INTRODUCTION

Technological advances in education have opened up significant opportunities for transforming learning models into more innovative and adaptive ones . One approach that is currently receiving widespread attention is game-based learning (GBL), a learning strategy that utilizes game elements to create a fun and meaningful learning experience . However , the effectiveness of GBL cannot be measured solely by student engagement ; it also needs to be oriented toward developing higher - order thinking skills (HOTS), which include analytical , evaluation , and creative abilities , as outlined in the revised Bloom 's taxonomy . In the era of increasingly fierce

global competition , critical thinking and numeracy literacy are essential competencies that students must possess from the elementary school level . The reality on the ground shows that many elementary school students , including those in remote areas such as Parigi Moutong Regency , still face serious challenges in developing these two competencies , one of which is caused by conventional learning approaches . which tends to be teacher- centered and less stimulating for students' active thinking processes (Rahayu & Syahrul, 2024) .

Numeracy literacy is one of the basic competencies measured in Indonesia 's national assessment , and the results consistently show low student achievement in areas with limited educational resources (Salma Pasa Shahira, 2024) . Meanwhile , critical thinking skills , which are a core part of HOTS, have not yet developed optimally among fourth- grade elementary school students , considering that this age is actually a crucial phase in the formation of analytical thinking patterns . Various research results indicate that game- based learning designed with HOTS content can encourage students to not only remember or understand content , but also train their abilities in solving problems , reasoning logically , and making evidence - based decisions (Hayati & Aisyah, 2025) . Thus , the integration of HOTS into game-based learning designs is a relevant strategic step to address the challenges of learning quality at the elementary school level .

Several previous studies have explored the use of GBL in various learning contexts . Good educational game design must consider cognitive principles for effective learning . Research (Khotimah et al., 2026) shows that digital- based games can significantly increase students' intrinsic motivation and cognitive engagement . In Indonesia, (Hikamudin et al., 2023) found that HOTS - based game-based learning positively influenced the critical thinking skills of elementary school students in Central Java, while (Pancasilawati et al., 2025) concluded that a similar approach significantly improved fourth- grade students' numeracy literacy compared to conventional methods . On the other hand , Wahyudi et al. (2021) emphasized the importance of contextualizing learning media to local socio -cultural conditions for effective and sustainable educational interventions . Meanwhile, (Shandilia et al ., 2024) in their recent study emphasized that GBL implementation in rural elementary schools still faces obstacles in terms of infrastructure readiness and teacher competency , necessitating a simpler yet pedagogically rich design . Furthermore , (Fakhriyah et al., 2024) found that synergy between game elements and HOTS -based questions are consistently able to improve students' analytical skills in mathematics subjects , while (Dhani, 2025) added that the GBL approach based on numeracy adapted to local characteristics has proven to be more effective in improving students' thinking competencies in elementary schools in the interior of Central Sulawesi.

Although these studies have made important contributions , there is a research gap that needs to be filled . Most existing studies focus on urban or semi-urban contexts with relatively adequate facilities , so their findings cannot necessarily be generalized to the context of elementary schools in remote areas such as SDN Lambunu, Parigi Moutong Regency, which have limited infrastructure but equally pressing pedagogical needs . In addition , research that simultaneously measures the effect of HOTS - based GBL on two variables at once , namely critical thinking skills and numeracy literacy , in fourth - grade students is still very limited . The novelty of this study lies in the design of a learning intervention that explicitly integrates HOTS principles into the mechanics of an educational game , which is then implemented in a specific geographic and demographic context , namely fourth - grade students of SDN Lambunu , Parigi Moutong Regency , Central Sulawesi . This approach also contributes to the

development of an inclusive and contextual learning model for 3T areas (frontier , outermost , lagging).

Based on the description above , the problem formulation in this study is : is HOTS - based game-based learning effective for critical thinking skills and numeracy literacy of fourth- grade students of SDN Lambunu , Parigi Moutong Regency ? The purpose of this study is to describe and analyze the effectiveness of this approach on both competencies . Theoretically , this study is expected to enrich the treasury of basic education science , especially in the development of innovative HOTS - based learning models . Practically , the results of this study can be a reference for teachers , principals , and educational policy makers in designing more relevant and impactful learning strategies , especially in areas with limited resources .

RESEARCH METHODS

This study used a quantitative approach with a quasi-experimental design method , which was chosen because it was impossible to conduct full randomization of research subjects as is common in the context of formal education in schools . The design applied was a nonequivalent control group design, in which there were two groups , namely the experimental class that received treatment in the form of HOTS- based game-based learning and the control class that continued to use conventional methods , but without a random assignment process . Both groups were given a pretest before treatment and a posttest after treatment to measure changes in students' critical thinking skills and numeracy literacy in a measurable and systematic manner. This approach is considered appropriate because it allows researchers to test the causal relationship between the independent and dependent variables in conditions that are close to real situations in the field without disrupting the existing class structure (Creswell, 2023) .

The population in this study were all fourth- grade students of Lambunu Elementary School , Parigi Moutong Regency , with the sample determined using a purposive sampling technique based on the equality of the initial academic characteristics of the two classes used as research subjects . The instruments used included pretest and posttest question sheets that had been validated in content and construct by experts , as well as a critical thinking ability assessment rubric developed referring to HOTS indicators . Data were analyzed using independent sample t-test and N-gain score to measure the magnitude of student competency improvement in both groups . Before testing the hypothesis , prerequisite tests were conducted in the form of the Shapiro-Wilk normality test and Levene's homogeneity test to ensure that parametric statistical assumptions were met . The entire research procedure was designed systematically to produce valid, reliable , and scientifically accountable data (Sugiyono, 2022) .

RESULTS AND DISCUSSION

Description of Pretest and Posttest Data

Before presenting the results of the inferential testing , it is necessary to first present a general overview of the data on students' critical thinking skills and numeracy literacy in both groups . Data were obtained through a pretest conducted before the treatment was administered and a posttest after all learning sessions were completed . The following presents a summary of the descriptive statistics for both groups .

Table 1. Descriptive Statistics of Pretest and Posttest Critical Thinking Skills

Group	N	Mean Pretest	Mean Posttest	Std. Dev. Pretest	Std. Dev. Posttest
Experiment	28	52,64	81,43	7,32	6,18
Control	28	51,89	64,57	7,14	7,05

The data in Table 1 shows that before the treatment was given , both groups had relatively equal average critical thinking skills , namely 52.64 in the experimental group and 51.89 in the control group . This indicates that the initial conditions of the two groups were homogeneous and could be compared fairly . After the intervention was implemented , there was a much more significant increase in the experimental group with a posttest average reaching 81.43, compared to the control group which only reached 64.57. A similar pattern is also seen in the numeracy literacy data as presented in the following table.

Table 2. Pretest and Posttest Descriptive Statistics for Numeracy Literacy

Group	N	Mean Pretest	Mean Posttest	Std. Dev. Pretest	Std. Dev. Posttest
Experiment	28	50,18	79,86	6,95	5,87
Control	28	49,75	62,43	7,08	6,74

Table 2 confirms that the experimental group's numeracy literacy achievement experienced a significant jump from 50.18 to 79.86 , while the control group only increased from 49.75 to 62.43 . The difference in the posttest mean between the two groups of 17.43 points provides an initial indication that the HOTS - based game-based learning treatment provides a more optimal impact than conventional learning .

Prerequisite Test

Before hypothesis testing is carried out , a normality test is first carried out using Shapiro-Wilk and a homogeneity test using Levene's test to ensure that the parametric statistical assumptions are met .

Table 3. Results of the Shapiro-Wilk Normality Test

Variables	Group	Statistik W	Say.	Information
Critical thinking	Experiment	0,967	0,512	Normal
Critical thinking	Control	0,971	0,583	Normal
Literacy Numeracy	Experiment	0,963	0,447	Normal
Literacy Numeracy	Control	0,958	0,391	Normal

The results of the normality test in Table 3 show that all posttest data , both in the experimental and control groups , have a significance value above 0.05. Thus , the data distribution in all groups is declared normal and meets the assumptions for proceeding to parametric testing .

Table 4. Results of Levene's Test of Homogeneity

Variables	F	Say.	Information
Critical thinking	1,243	0,271	Homogeneous
Literacy Numeracy	1,187	0,281	Homogeneous

Based on Table 4, the significance value of Levene's test for both variables is above 0.05 , namely 0.271 for critical thinking skills and 0.281 for numeracy literacy . These results confirm that the variance of both groups is homogeneous , so that hypothesis testing using the independent sample t-test can be carried out validly .

Hypothesis Testing (Independent Sample T-Test)

Hypothesis testing was conducted to determine whether there was a significant difference between the experimental and control groups after the treatment was given . The hypothesis tested was : there is a significant difference in critical thinking skills and numeracy literacy between students who learn using HOTS - based game-based learning and students who learn conventionally .

Table 5. Results of the Independent Sample T-Test

Variables	**t count**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Information**
Critical thinking	9,847	54	0,000	16,86	Significant
Literacy Numeracy	10,213	54	0,000	17,43	Significant

Table 5 shows that the significance value (p-value) for both variables is 0.000, which is much smaller than the significance level of $\alpha = 0.05$. The calculated t-value for critical thinking ability is 9.847 and for numeracy literacy is 10.213, both exceeding the t- table value at df = 54. This means that H_0 is rejected and H_1 is accepted , so it can be concluded that there is a significant difference between the two groups , and HOTS - based game-based learning is proven to be more effective in improving critical thinking skills and numeracy literacy of fourth- grade students at SDN Lambunu .

N-Gain Score Analysis

To measure the effectiveness of the treatment in more detail , the N-gain score was calculated for each variable for both groups . The N-gain interpretation categories followed Hake's criteria , namely high (> 0.70), medium (0.30–0.70), and low (< 0.30).

Table 6. Results of N-Gain Score Calculation

Variables	Group	Mean Pretest	Mean Posttest	N-Gain	Category
Critical thinking	Experiment	52,64	81,43	0,61	Currently
Critical thinking	Control	51,89	64,57	0,26	Low
Literacy Numeracy	Experiment	50,18	79,86	0,60	Currently
Literacy Numeracy	Control	49,75	62,43	0,25	Low

The data in Table 6 shows that the experimental group obtained an N-gain score of 0.61 for critical thinking skills and 0.60 for numeracy literacy , both of which fall into the medium

category but are at the upper limit of the category . In contrast , the control group only obtained an N-gain of 0.26 and 0.25, both of which are classified as low . The quite striking difference in N-gain between these two groups further strengthens the finding that HOTS - based game-based learning interventions make a real contribution to improving student competency , although the increase has not yet reached the high category , which can be an important note for improving learning design in future research .

DISCUSSION

The Effectiveness of HOTS -Based Game-Based Learning

The results of statistical testing show that the application of HOTS - based game-based learning has a significant influence on improving the critical thinking skills of fourth- grade students at Lambunu Elementary School . The t-test significance value is 0.000 ($p < 0.05$) with the average posttest of the experimental group reaching 81.43, far exceeding the control group which only obtained 64.57. This finding is in line with the results of studies (Sanki, 2025) which consistently found that the integration of the Problem Based Learning model with Game-Based Learning has been proven to have a positive impact on students' critical thinking skills , both at the elementary and secondary school levels . The competitive and collaborative elements embedded in the game mechanism encourage students to not only receive information passively , but to actively analyze situations , evaluate options , and make decisions independently , which are the core of the critical thinking process .

Furthermore , the findings of this study are also reinforced by (Yeningsih et al., 2025) who found that the game- based learning model , in this case the Teams Games Tournament (TGT), was able to produce an N-gain of 0.63 in the critical thinking skills of fifth- grade elementary school students , far exceeding the control group which only achieved 0.08. This result is very relevant to the N-gain achievement in this study of 0.61 for the critical thinking skills of the experimental group , which shows the consistency of the effectiveness of the game- based approach across elementary school contexts . Game mechanisms that stimulate curiosity , cognitive challenges , and immediate feedback have been proven to be able to create learning conditions conducive to the development of higher -order thinking skills . In addition , (Faradillah, 2025) also confirmed that the use of game- based media such as Baamboozle significantly improved the critical thinking skills of elementary school students , with a significant difference between pretest and posttest scores based on a paired t-test . These three findings collectively confirm that game designs oriented towards problem solving and high-level reasoning High is a robust and proven learning strategy for developing critical thinking skills in elementary schools .

The Effectiveness of HOTS -Based Game-Based Learning

In the numeracy literacy dimension , the results of this study also showed a significant difference between the experimental and control groups , with an average posttest of 79.86 compared to 62.43 in the control group , and a significance value of 0.000 ($p < 0.05$). The experimental group's N-gain score of 0.60 is in the moderate category and is substantially higher than the control group's of only 0.25 . This achievement has strong alignment with the findings of (Ni'mah, 2024) , which proves that the game-based learning model assisted by digital media Geometry Dash has a positive and significant effect on the numeracy abilities of third-grade elementary school students , with a calculated t value of 5.402 which exceeds the t table at a

significance level of 5 %. This indicates that the basic principles of GBL in improving numeracy literacy are consistent even though they are applied in different game contexts and levels .

Similar findings were also reported by (Fajriyah, 2025) who implemented game-based learning to improve literacy and numeracy of elementary school students in Semarang, with numeracy achievement increasing from 53% in the first cycle to 89% in the second cycle . This substantial increase confirms that the game- based approach is able to create a contextual and enjoyable learning experience , so that students more easily build mathematical conceptual understanding . (Aini et al., 2026) in their research also strengthens this argument by finding that the innovative learning approach based on AKM questions produces an N-gain of 0.42 in the moderate category , which is parallel to the findings of this study , while also indicating that increasing numeracy literacy through non- conventional interventions does tend to be in the moderate range for the context of elementary school students . (Laela Abidatul Itriani, 2026) through her literature study also confirms that GBL consistently improves elementary school students' mathematics learning outcomes because this model is able to boost intrinsic motivation and active participation of students in the learning process .

Comparison of Effectiveness between Experimental and Control Groups

Overall , the comparison of the results between the experimental and control groups on both variables shows the consistent superiority of the HOTS-based game-based learning approach. This finding is further supported by a study conducted with 60 fourth-grade elementary school students who found that traditional Balogo game-based learning significantly improved numeracy literacy and critical thinking skills compared to conventional learning , with the t - test results showing $p < 0.05$. The similarity of the research design , namely the quasi - experimental nonequivalent control group with the fourth - grade elementary school subjects , makes (Agung et al., 2025) the most relevant comparative reference and strengthens the external validity of the findings of this study .

Furthermore , (Isnaini & Sani, 2025) also found that crossword - assisted GBL effectively improves student learning outcomes with a significance value of $p < 0.001$, which indicates that the game-based learning framework in its various variations , including those based on HOTS as in this study , consistently produces significant differences in achievement compared to conventional methods . (Dhyfa et al., 2025) also added an important perspective that innovatively developed numeracy - based instruments are able to detect the distribution of student abilities more accurately , which strengthens the urgency of using assessments that are aligned with game- based learning approaches to obtain a comprehensive picture of achievement . Overall , the evidence from all the references reviewed coherently supports the conclusion that HOTS - based game-based learning is an effective pedagogical intervention and is worthy of wider implementation in elementary schools , especially in the context of improving students ' critical thinking skills and numeracy literacy .

CONCLUSION

This study produced findings that confirmed that the application of HOTS - based game-based learning was significantly effective in improving the critical thinking skills and numeracy literacy of fourth- grade students at Lambunu Elementary School , Parigi Moutong Regency . This was proven through a t-test significance value of 0.000 ($p < 0.05$) in both variables , with the experimental group's posttest mean for critical thinking reaching 81.43 and numeracy

literacy at 79.86, both far exceeding the control group's achievements . The N-gain score results of 0.61 and 0.60 in the moderate category further strengthen the evidence that game- based learning interventions oriented towards higher -order thinking skills are able to encourage students' cognitive development more optimally than conventional approaches . Thus , HOTS - based game -based learning is worthy of consideration as an alternative innovative and contextual learning strategy in elementary schools .

Based on the findings of this study , several important recommendations need to be conveyed . First , fourth- grade elementary school teachers , especially in the Parigi Moutong Regency area , are advised to adopt a HOTS- based game -based learning approach as part of their daily learning strategy repertoire . Second , the design of educational games should include indicators of critical thinking and numeracy explicitly so that the cognitive stimulus provided is more focused . Third , the education office needs to facilitate training for teachers related to the design and implementation of HOTS- based GBL , considering that limited pedagogical competence in remote areas remains a real obstacle . Fourth , further researchers are recommended to expand the research subjects and add moderating variables such as learning styles or student motivation to obtain a more comprehensive picture of the effectiveness of this approach in various learning contexts .

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