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Photomath-assisted contextual learning and students' mathematical reasoning: examining the role of logical-mathematical intelligence

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PHOTOMATH-ASSISTED CONTEXTUAL LEARNING AND STUDENTS' MATHEMATICAL REASONING: EXAMINING THE ROLE OF LOGICAL-MATHEMATICAL INTELLIGENCE

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ABSTRACT

This study aims to examine the effect of Photomath-assisted contextual learning on students' mathematical reasoning and to investigate the moderating role of logical-mathematical intelligence in the relationships between learning and mathematical reasoning at Islamic Junior High School Madrasah Tsanawiyah (MTs) Al Washliyah Tanjung Morawa. This study employs a quantitative approach with a quasi-experimental pretest-posttest control group design. The study population consisted of 129 eighth-grade students. Using purposive sampling, two classes were selected: 31 students in the experimental class and 32 students in the control class. The research instruments consisted of a mathematical reasoning test and a logical-mathematical intelligence questionnaire. The data were analyzed using an independent-samples t-test and two-way ANOVA (2×2). The data were analyzed using an independent-samples t-test, which showed no statistically significant difference in logical-mathematical intelligence scores between the experimental and control groups, $t(61) = 1.662, p = 0.102$. The two-way ANOVA revealed a statistically significant main effect of the learning class on students' mathematical reasoning, $F(1,59) = 83.551$, $p < 0.001$. In contrast, the main effect of logical-mathematical intelligence was not statistically significant, $F(1,59) = 0.215$, $p = 0.644$. The interaction between learning style and logical-mathematical intelligence was also not statistically significant, $F(1,59) = 0.456$, $p = 0.502$. Thus, logical-mathematical intelligence did not have a statistically significant moderating effect on the relationships between learning style and students' mathematical reasoning.

Keywords: Contextual Learning, Photomath, Logical-Mathematical Intelligence, Student Reasoning, Moderator

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INTRODUCTION

Mathematics has become a lens through which people view their daily lives. Mathematics also serves as the foundation for the advancement of science and the latest developments in technology and information (Hidayatulloh et al., 2024). Therefore, mathematics is an important foundational subject to study because it facilitates understanding of other fields of study and supports its application in everyday life. Without realizing it, students often use mathematical concepts, such as estimating the number of items. If learning is linked to situations commonly encountered in daily life, the material will be easier to understand and less boring (Nuraini et al., 2020). Presenting engaging, enjoyable learning objectives is a viable alternative approach to achieve this; teachers must be innovative in selecting the right teaching strategies and resources (Nurdin et al., 2020).

Mathematics plays a crucial role in developing students' rational and logical thinking because its concepts are closely interrelated. However, mathematics instruction should not only emphasize the presentation of theories and procedures but also provide students with opportunities to actively construct knowledge and develop mathematical reasoning (Fathinatusholihah et al., 2024).

One of the internal factors that can influence student learning outcomes is intelligence. İntelligence is the most important psychological factor in the learning process and determines the quality of students' learning. To date, logical-mathematical intelligence remains the primary measure of an individual's intelligence level and serves as a strong indicator of students' learning achievements (Hana & Sucilestari, 2020).

In reality, some students feel that mathematics is a stressful and unpopular subject, which ultimately makes it difficult for them to understand. Logical-mathematical intelligence is the most important skill students need to possess when learning mathematics. For middle school students, logical-mathematical intelligence is essential. This is because when solving math problems, students need mathematical logic skills. With logical-mathematical intelligence, students can be said to possess critical thinking, creative thinking, deductive reasoning, inductive reasoning, and other skills. Since logical-mathematical intelligence encompasses many skills (Erlina & Hakim, 2019).

Learning mathematics also requires the ability to reason mathematically. However, according to data from the 2019 Programme for International Student Assessment (PISA), Indonesia ranked 72nd out of 78 countries in mathematical ability. A similar situation was observed in the Trend in International Mathematics and Science Study (TIMSS), which placed Indonesia 44th out of 49 participating countries, as detailed in a number of additional studies. In terms of student achievement, 54 percent fall into the low category, 15 percent at the moderate level, and only 6 percent at the moderate level, and only 6 percent at the high level in terms of mathematical proficiency. The information obtained from PISA and TIMSS indicates that the quality of mathematics education in Indonesia remains far from adequate. This indicates that the primary objectives of mathematics education have not yet been fully achieved (Ariati & Juandi, 2022).

One approach to supporting mathematics learning is the use of technology as a learning resource. Digital technology can provide students with opportunities to explore mathematical concepts and obtain support when solving problems. One application that can be used in mathematics learning is Photomath, which provides step-by-step solutions to mathematical problems. When integrated appropriately into contextual learning, Photomath may support students in understanding the procedures involved in solving mathematical problems while connecting mathematical concepts with real-life situations.

Today's rapid technological advancements are impacting how media is used in education, and this influence is growing. One example is educational media that incorporates multimedia elements via Android apps, such as Photomath, which can be downloaded from the Play Store, making it easy for students to use and learn from. Photomath is a math problem-solving app that works by scanning a problem through the camera; it displays the solution in a matter of seconds, making this software a great time-saver when tackling math problems. Currently, Photomath can identify and solve math problems such as decimals, fractions, arithmetic, square roots, integrals, and basic linear equations. Using the Photomath Android app gives students the opportunity to solve problems related to the Pythagorean theorem in a focused and systematic way, as the app guides them through the steps of the solution. Therefore, for children who want to learn to solve math problems quickly and easily, Photomath can be a useful resource. In this context, teachers facilitate learning by creating an engaging environment that makes learning meaningful and maximizes learning objectives (Handayani & Solihah, 2022).

A study conducted by Arsy Handayani, titled "The Effectiveness of Using the Photomath App in Increasing the Learning Motivation of Eighth-Grade Students at Bajo State Junior High School 2," revealed a notable 29.85% increase in the average learning motivation scores of students, as measured by a questionnaire. Prior to using the Photomath app, the average questionnaire score was 53.15%, which falls into the low learning interest category. After using the app, the average score increased to 83%, which falls into the very high learning interest category (Arsy Handayani, 2020).

The rationale for this study is based on the potential of Photomath as a supplementary learning tool to support students' mathematical reasoning through step-by-step and systematic mathematical solutions. By presenting the stages of mathematical of mathematical procedures, Photomath may help students recognize the logical relationships involved in mathematical concepts rather than merely obtaining the final answer. When integrated with contextual learning, the application may also support students in connecting mathematical concepts with situations encountered in everyday life, particularly in learning topics such as the Pythagorean theorem.

Students at Islamic Junior High School (MTs) Al Washliyah Tanjung Morawa, logical-mathematical intelligence may influence how they respond to technology-assisted mathematics learning. Based on the distribution of logical-mathematical intelligence scores in this study, 33 students $(52{,}38\%)$were categorized as having high logical-mathematical intelligence, while 30 students $(47{,}62\%)$ were categorized as having low logical-mathematical intelligence. This variation indicates that students have different levels of logical-mathematical intelligence, particularly in their ability to think logically, recognize patterns and relationships, classify information, and use logical reasoning. Students with higher logical-mathematical intelligence may be more readily able to engage with the logical structure of mathematical concepts presented through Photomath, whereas students with lower logical-mathematical intelligence may require more guidance to understand and interpret these logical relationships. Therefore, the effect of Photomath-assisted contextual learning on students' mathematical reasoning may vary according to their level of logical-mathematical intelligence. This provides a conceptual and statistical basis for examining logical-mathematical intelligence as a potential moderator of the effect of the learning intervention on students' mathematical reasoning.

Students with high and low levels of logical-mathematical intelligence may differ in their ability to identify patterns, establish relationships, and process logical information when working on math problems. Therefore, students with different levels of logical-mathematical intelligence may respond differently to contextual learning supported by Photomath, particularly in developing mathematical reasoning. This possibility provides a conceptual foundation for examining the moderating role of logical-mathematical intelligence in the relationship between learning interventions and students' mathematical reasoning.

In addition, the use of apps like Photomath, which present step-by-step problem-solving solutions, is believed to help students understand the logical thought process involved in solving math problems, rather than just the final answer. This can indirectly develop students' reasoning skills and strengthen their mathematical and logical intelligence. By utilizing contextual and technology-assisted approaches, the learning process is expected to not only be more engaging but also to more effectively help students build conceptual understanding, enhance higher-order thinking skills, and develop systematic reasoning abilities.

Based on this description, learning can be understood as a process involving active interaction among students, teachers, and learning resources to support students in acquiring information, skills, attitudes, and confidence through planned efforts by educators. Learning is carried out effectively and efficiently using organized techniques, thereby producing optimal learning outcomes.

Contextual learning is an educational concept that helps teachers connect learning materials to real-life situations experienced by students. Through this approach, pupils are advised to link their existing knowledge to its application in daily life (Panjaitan, 2016). This approach motivates students to understand how the knowledge they learn in school can be used every day as members of society and as individuals. Thus, pupils do not just learn theoretically but are also able to connect lessons with real experiences and needs related to their living environment, making the learning process feel more meaningful (Simamora et al., 2020).

This type of context-based learning provides valuable support to students as they come to understand the realities of life through material that is familiar to them. In addition, this learning process also helps correct misconceptions or inaccurate prior knowledge, enabling students to rebuild their understanding correctly and apply it in their daily lives (Isrok'atun & Rosmala, 2018). In contextual learning, the teacher's role is to facilitate the students' learning process by providing appropriate learning resources and materials. Teachers do not merely focus on delivering material that requires rote memorization; rather, they are also responsible for managing the learning environment and implementing supportive learning strategies to enable pupils to engage actively in the lessons learnt (Rangkuti, 2018).

The contextual learning model comprises seven key elements that are essential to its implementation. These seven components are as follows: constructivism, inquiry, questioning, learning community, modelling, reflection, and authentic assessment. In the context of this study, several components are particularly relevant to the implementation of photomath-assisted contextual learning. The inquiry component encourages students to explore contextual Pythagorean problems and investigates solution procedures with Photomath as a supporting tool. The questioning component encourages students to examine and justify the mathematical steps involved in solving problems. Through the learning community component, students discuss their solution strategies. The reflection component provides opportunities for students to evaluate their learning process and the use of Photomath. Finally, authentic assessment focuses on students' ability to apply concepts and explain their mathematical reasoning rather than merely obtaining the correct answer.

Constructivism is understood as the process of building understanding; in the context of the philosophy of education, it can be interpreted as an effort to build a modern, culturally enriched way of life. Through constructivist theory, students are encouraged to think actively when solving problems and making decisions independently. Students gain a deeper understanding because they are directly involved in developing new knowledge; this active engagement also makes students better able to apply the concepts they have learned and helps them retain those concepts for a longer period of time (Wahab & Rosnawati, 2021).

According to Piaget, an individual's thinking ability or intellectual intelligence develops gradually through several stages. Cognitive development begins with the sensorimotor stage, when children explore the world through sensory and motor activities, and then progresses to the preoperational stage, characterized by the emergence of symbolic functions and preconceptual thinking skills. Subsequently, in the concrete operational stage, children begin to perform logical operations on real objects, eventually reaching the formal operational stage, where individuals are capable of abstract, logical, and reflective thinking. Thus, a person's intellectual development does not occur suddenly but through a gradual process in accordance with their age and experiences (Babullah, 2022).

According to Vygotsky, a person's cognitive development is inextricably linked to social interactions with their surroundings. Through ideas about the Zone of Proximal Development (ZPD), Vygotsky expands on the idea that learners have the potential to achieve higher levels of competence if they receive scaffolding tailored to their capabilities. In the context of modern learning, teachers play a crucial role as facilitators who provide step-by-step assistance so that students can learn independently and enhance their higher-order thinking skills (Wardani et al., 2023).

Furthermore, Jean Piaget and Vygotsky emphasize the social aspect in relation to its relevance to the learning process. Interactions during group learning activities are considered to help students develop a better conceptual understanding (Baharuddin & Wahyuni, 2015). Therefore, this section will examine the ideas of Jean Piaget and Vygotsky regarding the learning process as the basis for applying the constructivist approach in teaching. Jean Piaget's Constructivist Theory of Learning, from a constructivist perspective, knowledge is not acquired instantly but develops through an individual's experiences. A person's understanding becomes stronger and deeper as they continue to engage with new experiences during the learning process. According to Piaget, humans possess systematically organized knowledge structures in their minds, each of which has a distinct meaning and is interconnected with the others. Vygotsky Contructivist Theory of Learning, one of the fundamental concepts of the constructivist approach to learning is the social interaction between individuals and their environment. According to Vygotsky (Elliot, 2003), learning is a process comprising two elements. Firstly, the act of learning is a biological process at its most basic level. Second, it is a psychosocial process at a higher level, the essence of which is linked to the sociocultural environment.

Utilization of media in the classroom can make various lesson environments more engaging, thereby fostering positive relationships between teachers and students. In addition, educational media can help reduce student boredom by motivating them through the effective use of media, not only in the classroom but also outside of it. If utilized to the fullest, these resources can help achieve learning objectives more quickly (Nurfadhillah, 2021).

From a pedagogical perspective, educational media contribute to children's psychological development in the learning process. Educational media serve as tools that help students better understand the material, particularly by making abstract concepts more concrete and easier to grasp (Nurfadhillah, 2021). Mathematics is the study of basic formulas used for calculations. In this subject, pupils do not just learn to comprehend formulas but also apply them to solve various practical problems, including both numerical problems and word problems. Logic and critical thinking are essential when studying mathematics to solve challenging problems.

Mathematics is the subject that studies the basic formulas used for calculations. In this subject, pupils not only learn to understand those formulas, but also to apply them in solving various practical problems-encountering problems not only in numerical form, but also in the form of word problems. Logic and critical thinking are essential when studying mathematics in order to solve challenging problems. As technology advances, the learning process is undergoing significant transformation. Technology opens up opportunities for students to access various learning materials and resources in a more efficient and flexible way. One such example is the Photomath app, developed by MicroBlink, a Croatian company founded in 2011. It has become a popular tool among students and can help anyone solve difficult math problems. Thanks to its advanced capabilities, Photomath quickly provides accurate and comprehensive solutions to math problems, complete with detailed explanations.

Photomath is an innovative app that leverages technology to support math learning. With its ability to provide instant answers and step-by-step explanations, this app is a valuable tool for students in building their understanding and solving math problems systematically. Photomath offers various features that make it easy for users to enter math problems, either manually or by scanning them with a phone camera. Once a solution is displayed, the app provides step-by-step guidance so users can understand the process of solving the problem.

Solution diagrams and animated instructions help users solve problems step by step from start to finish.

Photomath is an easy-to-use app for solving math problems using two methods. Firstly, users can enter problems manually via the edit feature, which features a calculator-style keyboard. Secondly, users simply need to point their mobile phone's camera at the problem to scan it directly; it will be automatically scanned within the frame displayed on the screen. After selecting one of these methods, users are directed to the 'Solution' page, which displays a graphical representation of the solution along with the steps involved in an animated format. This makes it easier for users to understand the problem-solving process. Photomath sometimes encounters difficulties with its camera-based character, number, and symbol recognition function, meaning that the captured image often differs from the original and makes it difficult to solve problems. Furthermore, the app is unable to solve all types of equations, particularly complex ones or those involving symbols from several different apps at once.

Mathematical-logical intelligence is a skill that combines numerical ability with logical reasoning. In the context of mathematical reasoning and intelligence, it can be defined as an individual's ability to reason logically to solve problems and perform mathematical calculations (Saleh et al., 2024). Asri Budiningsih's perspective emphasizes that logical-mathematical intelligence is often associated with scientific thinking, which is a thought process that prioritizes logic, whether in deduction or induction. In short, this means that logical-mathematical intelligence requires the ability to construct arguments based on logical truth (Saleh et al., 2024).

Logical mathematical intelligence reflects critical thinking as applied in the scientific method. People with this type of intelligence enjoy working with data, organizing, analyzing, interpreting, and drawing conclusions from it. They also tend to recognize patterns and relationships among data and enjoy solving math problems or playing strategy games. Thus, the development of logical mathematical intelligence involves not only cognitive aspects but also the application of concepts in practical, everyday situations (Saleh et al., 2024).

In this context, logical-mathematical intelligence encompasses some key aspects. Firstly, the ability to handle numbers and perform mathematical operations is a key element. Someone with good logical-mathematical intelligence can easily carry out calculations, take measurements, and understand complex mathematical concepts. Secondly, the ability to recognise patterns and apply logical thinking is essential. This involves the capacity to identify mathematical trends, make predictions and formulate solutions based on logical thinking (Saleh et al., 2024). Note that important to note that logical mathematical intelligence is not merely a matter of arithmetic skills, but also involves the ability to solve problems logically and scientifically. According to Howard Gardner, a cognitive psychologist, the human brain possesses at least nine recognized types of intelligence, known as multiple intelligences (Saleh et al., 2024).

Overall, logical-mathematical intelligence is a complex skill that encompasses numeracy, scientific thinking, and the application of logic to solve mathematical problems. This ability is highly relevant in the context of education, as it involves various aspects of intelligence that can be developed and expanded through effective mathematics teaching (Saleh et al., 2024). To assess pupils' logical-mathematical intelligence, there are several methods that can be implemented; first and foremost, accurate assessment is the first step in measuring this ability. Pupils can be tested with questions that assess their logical-mathematical abilities, enabling them to apply critical thinking to solve mathematical problems.

Howard Gardner developed a theory that categorises various types of intelligence (multiple intelligences), including logical-mathematical intelligence as one of them (Indaswari et al., 2021) According to (Asmal, 2020), logical-mathematical intelligence indicators are as follows:

Table 1. Indicators of logical-mathematical intelligence according to (Asmal, 2020)

Variabel	Indikator	Sub indicator
Logical-mathematical intelligence	Numeracy	a. Determining the results of mathematical calculations
	Reasoning skills	a. To raise an allegation b. Mathematical manipulation c. Presenting conclusions, evidence and reasons. d. Validity of the argument e. Identifying patterns in mathematical phenomena to draw generalizations
	logical thinking	a. Given that b. Comparing c. Analyzing d. In conclusion
	Problem-Solving	a. Understanding the problem b. Drawing up a settlement plan c. Implementing the settlement plan d. Double-check

Student reasoning is the ability to think methodically so that one can draw conclusions based on certain facts or assumptions. Student reasoning is a thought process that requires analysis skills to evaluate information logically based on what is already known. In mathematics education, reasoning is a crucial element because it helps students build mathematical models and find solutions to problems they encounter, both in academic settings and in everyday life (Rahman et al., 2019). Reasoning is a logical thinking process used to analyze, evaluate, and organize information in order to solve a problem and draw logical conclusions. Indicators of student reasoning include: 1) Presenting explanations using patterns, facts, characteristics, and relationships; 2) Drawing logical conclusions; 3) Predicting outcomes and identifying solutions; 4) Gathering valid arguments (Asoraya & Ruli, 2023).

(Relawati, 2021) The study found that both simple and multiple regression and correlation analyses indicated that logical-mathematical intelligence influences the mathematical reasoning abilities of eighth-grade students at SMPN 23 Muaro Jambi. The study reported a correlation coefficient of 0.39318, indicating that the relationship between logical-mathematical intelligence and mathematical reasoning abilities falls into the weak category.

A systematic literature review on the use of the Photomath app as a learning tool indicates that Photomath has the potential to support mathematics learning and improve students' competencies by presenting solution steps in a systematic manner. These findings suggest that Photomath can serve as a technological tool to support the mathematics learning process. However, the use of this app should not lead students to become dependent on it but rather serve as a support tool to help them understand how to solve problems independently. Nevertheless, this study has not specifically examined the effect of using Photomath in contextual learning on students' logical-mathematical intelligence and mathematical reasoning skills, nor has it tested the role of logical-mathematical intelligence as a moderator variable (Zahra & Yahfizham, 2024).

Based on previous research findings, contextual learning has been linked to the development of students' mathematical reasoning, while logical-mathematical intelligence has also been shown to be related to mathematical reasoning ability. In addition, Photomath has been identified as a potential technological tool to support mathematics learning through systematic, step-by-step problem solving. However, previous studies have generally examined these aspects separately. Few studies have specifically investigated photomath-assisted contextual learning while simultaneously considering students' logical-mathematical intelligence as a moderator variable in relation to mathematical reasoning. Therefore, this study offers a different perspective by examining whether the effect of photomath-assisted contextual learning on students' mathematical reasoning varies according to their level of logical-mathematical intelligence.

A preliminary study conducted on 63 students showed that the students' logical-mathematical intelligence varied from one individual to another. Based on questionnaire scores, 33 students were categorized as having high logical-mathematical intelligence, while 30 students were categorized as having low logical-mathematical intelligence. This variation suggests that students may have different levels of readiness in understanding, processing, and using mathematical information during the learning process. Students with higher logical-mathematical intelligence may be better able to identify relationships, recognize patterns, and follow systematic problem-solving steps, whereas students with lower logical-mathematical intelligence may require greater learning support when engaging with contextual mathematical tasks. Therefore, the level of logical-mathematical intelligence may influence how students respond to contextual learning facilitated by Photomath.

Therefore, this study aims to investigate the effect of Photomath-assisted contextual learning on students' logical-mathematical intelligence and mathematical reasoning, as well as to examine the role of logical-mathematical intelligence as a moderator variable in the relationship between the learning approach and students' mathematical reasoning. This study hypothesizes that: 1) Photomath-assisted contextual learning has a significant effect on students' logical-mathematical intelligence; 2) Photomath-assisted contextual learning has a significant effect on students' mathematical reasoning; and 3) Logical-mathematical intelligence acts as a moderator of the effects of Photomath-assisted contextual learning on students' mathematical reasoning.

METHOD

This study employed a quasi-experimental design using a pretest-posttest control group design. The study was conducted at Islamic Junior High School (MTs) Al Washliyah Tanjung Morawa, where students were distributed across four classes. The population consisted of 129 students. The sample was selected using purposive sampling. Two classes were selected as the research sample: class VIII-1 as the experimental consisting of 31 students, while class VIII-2 consisted of 32 students and served as the control class. Thus, the total sample consisted of 63 students.

Tools used in this study consisted of test and non-test instruments. The essay test was used to measure students' reasoning abilities, meanwhile, a non-test instrument, a questionnaire, was used to measure students' logical-mathematical intelligence. The test instrument comprised four essay questions on the Pythagorean theorem, whilst the non-test instrument used a questionnaire to ascertain the pupils' responses regarding their experiences of solving Pythagorean theorem problems with and without Photomath.

The instrument used in this study consisted of a logical-mathematical intelligence questionnaire and a mathematical reasoning test. Indicators of logical-mathematical intelligence: 1) Numeracy (2 items), 2) reasoning ability (2 items), 3) logical thinking (6 items), 4) problem solving (7 items). Of the 22 items, 15 were positively worded, and 7 were negatively worded. The logical-mathematical intelligence questionnaire consisted of 22 items on a five-point Likert scale, with total scores ranging from 22 to 110. These scores were classified into five categories: excellent (93-110), good (75-92), adequate (57-74), poor (39-56), and very poor (22-38). The questionnaire was evaluated by two expert validators based on nine assessment aspects, and its content validity was analyzed using Aiken's V. The resulting coefficient was 0.875, which is categorized as excellent. Logical-mathematical intelligence was measured using a 22 item questionnaire, which was administered after the learning intervention and the final mathematical reasoning test. Questionnaire scores ranged from 22 to 110. The sample's median score of 70 was used as a cutoff point to classify students into high and low logical-mathematical intelligence, and 30 students were classified as having low logical-mathematical intelligence.

Mathematical reasoning skills are assessed using four essay questions on the Pythagorean theorem based on four reasoning indicators: 1) presenting mathematical explanations based on patterns, facts, properties, and relationships, 2) drawing logical conclusions, 3) predicting results and identifying solutions, and 4) providing valid arguments. Each question is scored on a scale of 0 to 5, so the maximum possible score is 20. The scoring criteria consider the completeness and correctness of the solution, the accuracy of the steps taken to arrive at the solution, and the mathematical arguments presented by the student the same scoring criteria are applied to all students. The same scoring criteria are applied to all students' answers to ensure consistency. This test was validated by two expert validators using Aiken's V and obtained a coefficient of 0.958333, which is categorized as very good.

In this study, the learning approach was treated as the independent variable, consisting of contextual learning aided by Photomath and conventional learning, while mathematical reasoning ability was treated as the dependent variable. Logical-mathematical intelligence was treated as a moderator variable and categorized into high and low levels for a 2×2 factorial analysis of variance (ANOVA). Questionnaire scores were used to classify students into high and low logical-mathematical intelligence groups. A median score of 70 was used as the cutoff point, resulting in 33 students in the high group and 30 students in the low group. Based on this cutoff point, 33 students were classified into the high-intelligence group and 30 students into the low-intelligence group.

Data analysis was conducted using SPSS version 27.0. Prior to hypothesis testing, normality was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, while homogeneity of variances was assessed using Levene's test. An independent samples t-test was used to test. An independent sample t-test was used to test the effect of the instructional treatment on students' logical-mathematical intelligence. For mathematical reasoning ability, a (2×2) factorial ANOVA was conducted with learning approach and logical-mathematical intelligence category as the two factors. This analysis tested the main effects of the learning approach and the logical-mathematical intelligence category, as well as their interaction effect. The interaction between the learning approach and the logical-mathematical intelligence category was used to test whether logical-mathematical intelligence moderates the effect of photomath-assisted contextual learning on students' mathematical reasoning ability.

RESULT

With reference to the results regarding the preliminary and final tests. Students who were given Pythagorean theorem problems using Photomath demonstrated superior performance compared to students who worked on the problems without Photomath.

Research findings

A pretest was administered before the intervention to assess the initial proficiency of students in both classes. The results regarding the pretest analysis are shown in Table 2.

Table 2. Descriptive Statistics of Pretest Results

Class	N	Highest Score	Lowest Score	Mean	Std.Dev
Experiment	31	45.00	15.00	28.87	8.53519
Control	32	40.00	0.00	11.88	11.8288

Table 3. Independent Sample Test

		Levene's test for equality of variances		t-test for equality of Means					95% confidence interval of the difference	
		F	**Sig**	**t**	**df**	**Sig. (2-taild)**	**Mean difference**	**Std. error difference**	**Lower**	**Upper**
Score Pretest_Reasoning	**Equal variance assumed**	2.628	.110	6.522	61	.001	16.996	2.606	11.785	22.207
	Equal variance not assumed			6.555	56.432	.001	16.996	2.593	11.803	22.189

Descriptive statistics for pre-test scores show that the experimental class ($n = 31$) had a mean score of 28.87 ($SD = 8.54$), while the control class ($n = 32$) had a mean score of 11.88 ($SD = 11.83$). Levene's test indicated that the assumption of homogeneity of variances was met, $F(1, 61) = 2.628$, $p = 0.110$. However, the independent samples t-test revealed a statistically significant difference in pretest scores between the experimental and control classes, $t(61) = 6.522$, $p < 0.001$. These results indicate that the two groups were not equivalent at the beginning of the study. Therefore, the pretest scores were included as a covariate in the subsequent ANCOVA to correct for the initial differences between the two groups.

Table 4. Analysis of Covariance (ANCOVA) of Posttest Mathematical Reasoning Scores Adjusted for Pretest Scores

Source	df	F	p	Partial η^2
Pretest	1	39.178	$< .001$	.399
Learning	1	11.330	.001	.161
Pretest*Learning	1	1.073	.304	.018
Error	59	-	-	-

Table 5. Adjusted Estimated Marginal Means of Posttest Mathematical Reasoning Scores

Estimates

Dependent Variable: Score_Posttest

Class	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
A1 (Contextual Learning with Photomath)	73.568[a]	2.913	67.740	79.397
A2 (Contextual Without Photomath)	53.488[a]	2.461	48.563	58.413

The estimated means marginal has been adjusted for the math reasoning score on the initial test (covariance = 20.2381)

Table 6. Descriptive Statistics of the Post-Test Result

Class	N	Highest Score	Lowest Value	on Average	Std.Dev
Experiment	31	100,00	55,00	80,16	14,2877
Control	32	80,00	25,00	44,53	16,0824

Descriptive statistics for the posttest scores showing experimental the class achieved an average mark of 80,16; in contrast, the control class had an average mark of 44,53. This difference indicates a significant improvement in the experimental group following the implementation of photomath-assisted contextual learning, compared to the control class, which maintained relatively consistent low scores through conventional instruction.

Table 7. Result Of The İndependent Sample T-Test For Logical-Mathematical İntelligence

Independent Samples Test

		Levene's test for equality of variances		t-test for equality of Means					95% confidence interval of the difference	
		F	Sig	t	df	Sig. (2tailed)	Mean difference	Std. error difference	Lower	Upper
Survey_Scores	Equal variance assumed	3.011	.088	1.662	61	.102	2.831	1.703	-.575	6.236
	Equal variance not assumed			1.654	54.941	.104	2.831	1.711	-.599	6.260

Table 8. Independent Samples t-test Result

Class	N	Mean	Std. Deviation	t	df	p
Experimental	31	72.58	7.728	1.662	61	.102
Control	32	69.75	5.663	1.654	54.941	.104

Based on the independent sample t-test, Levene's test indicated that the assumption of equal variances was met $(p = .088 > .05)$. Therefore, the equal variances assumed result was used. The t-test showed no statistically significant difference in logical-mathematical intelligence scores between the experimental and control groups, t(61) = 1.662, p = .102 >.05.

Table 9. Result of the 2×2 ANOVA on Students' Mathematical Reasoning Based on Learning Approach and Logical-Mathematical Intelligence Level

Tests Of Between-Subjects Effects
Dependent Variable: Skor_Posttest

Source	Type III Sum Of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20143.698[a]	3	6714.566	28.321	.000	.590
Intercept	238648.704	1	238648.704	1006.593	.000	.945
Class	19808.632	1	19808.632	83.551	.000	.586
Intelligence	51.007	1	51.007	.215	.644	.004
Class * Intelligence	107.997	1	107.997	.456	.502	.008
Error	13988.048	59	237.086			
Total	276800.000	63				
Corrected Totally	34131.746	62				

A. R Squared = .590 (Adjusted R Squared = .569)

With reference to the results of the two-way ANOVA, the following findings were obtained: The main effect of learning class (A) was statistically significant, with $p < .001$. This indicates that Photomath-assisted contextual learning had a statistically significant effect on students' mathematical reasoning. The main effect of logical-mathematical intelligence (B) was not statistically significant, with $p = .644$. Furthermore, the interaction between learning class and logical-mathematical intelligence $(A \times B)$ was not statistically significant, with

$$p = 502 > .05$$

Thus, the null hypothesis of no interaction is not rejected. This finding indicates that the present study did not provide statistically significant evidence of a moderating effect of logical-mathematical intelligence on the relationship between photomath-assisted contextual learning and students' mathematical reasoning under the conditions of the present study. The two-way ANOVA (2×2) was conducted to examine the effects of learning class and logical-mathematical intelligence, as well as their interaction, on students' mathematical reasoning. Overall, the findings indicate that Photomath-assisted contextual learning had a statistically significant effect on students' mathematical reasoning, whereas the main effect of logical-mathematical intelligence and its interaction with learning class were not statistically significant.

DISCUSSION

The results of this study indicate that contextual learning supported by Photomath has a significant effect on students' mathematical reasoning abilities after accounting for their initial abilities. Students who participated in contextual learning supported by Photomath demonstrated higher adjusted reasoning scores compared to those who participated in contextual learning without Photomath. These findings are consistent with previous research showing that Contextual Teaching and Learning (CTL) can support students' mathematical reasoning by connecting mathematical concepts to meaningful and real-life contexts (Astriani & Al Dhana, 2024). This is also consistent with various studies examining Photomath as a mathematics learning tool, which show that the app can support students' understanding by providing step-by-step solutions and facilitating access to mathematical explanations (Rifa'i & Yahfizam, 2024). Therefore, these findings suggest that integrating Photomath into contextual learning can provide additional support for students as they work on math problems, particularly by helping them analyze solution steps while remaining engaged in a meaningful mathematical context.

These findings can be understood theoretically from constructivist and sociocultural perspectives in learning. Piaget's theory of cognitive development emphasizes that students actively construct knowledge through interaction with their experiences, rather than simply receiving information from teachers. In the context of contextual mathematics learning, student are encouraged to relate mathematical concepts to meaningful situations and build their own understanding through problem-solving experiences. This perspective is complemented by Vygotsky's sociocultural theory, which emphasizes the importance of social interaction and guidance in the development of students' thinking. Specifically, the concept of the Zone of Proximal Development (ZPD) explains how students can complete tasks that exceed their current independent abilities with appropriate assistance or scaffolding from a teacher or more capable peers. In this study, teacher guidance, classroom interaction, discussion, and the use of Photomath as a learning aid may have provided step-by-step guidance that helped students solve math problems and develop their understanding. Thus, these findings align with the view that meaningful learning experiences, social interaction, and appropriate learning support can facilitate the development of students' mathematical reasoning.

The Positive contribution of contextual learning to students' mathematical reasoning can also be understood from the nature of the mathematical activities presented during the learning process. Mathematical reasoning requires students to identify relationships, connect mathematical concepts, develop logical arguments, and draw conclusions based on relevant information. Contextual learning provides opportunities for student to engage in meaningful mathematical situations, interpret problems, and connect mathematical concepts with their applications. This is supported by (Nurlinda et al., 2024), who found that the implementation of Contextual Teaching and Learning (CTL) supported by interactive media has a significant effect on students' mathematical reasoning abilities. Their quasi-experimental study also examined the interaction between students' prior mathematical abilities and this learning model, highlighting the importance of considering student characteristics when discussing mathematics learning outcomes. In this study, contextual activities also required students to work on meaningful math problems, while Photomath provided additional procedural support when students encountered difficulties. Thus, these learning activities may have encouraged students not only to arrive at a mathematical answer, but also to analyze relationships, understand procedures, and develop logical explanations during the problem-solving process.

Logical-mathematical intelligence is an individual characteristic that may be related to students' mathematical reasoning abilities. It encompasses the ability to recognize patterns and establish logical processes when solving problems. Previous research has examined mathematical reasoning ability from the perspective of logical-mathematical intelligence. (Prastika et al., 2021) investigated the mathematical reasoning abilities of junior high school students in terms of logical-mathematical intelligence and found differences in students' reasoning characteristics based on their levels of logical-mathematical intelligence. Their findings indicate that students' logical-mathematical characteristics are closely related to the ways in which they present mathematical ideas, identify relationships or patterns, develop solutions, and draw conclusions. These findings provide a foundation for considering logical-mathematical intelligence in research on mathematical reasoning. However, this study examines this variable from a different perspective by treating logical-mathematical intelligence as a potential moderator of the effect of photomath-supported contextual learning on students' mathematical reasoning. Thus, this study not only examines students' reasoning based on their level of logical-mathematical intelligence but also investigates whether the effects of learning vary across different levels of logical-mathematical intelligence.

On students' mathematical reasoning. This finding means that this study did not obtain sufficient statistical evidence to conclude that the effect of contextual learning supported by Photomath on mathematical reasoning varies according to students' levels of logical mathematical intelligence. These results should not be interpreted as evidence that this teaching approach is equally effective for all levels of intelligence. Rather, the results indicate that the interaction effect was not strong enough to be detected under the conditions of this study. Previous research on learning approaches that take into account students' individual characteristics has emphasized the importance of examining how student characteristic has emphasized the importance of examining how student characteristic and instructional treatments may interact in mathematics learning (Mulia & Meiliasari, 2023). Research on Ability-Treatment Interaction (ATI), for example, specifically considers students' abilities in relation to instructional treatments, suggesting that learner characteristics can be an important consideration when analyzing learning outcomes (Rahmawati, 2021). However, in this study, the absence of a significant interaction indicates that variations in the effects of contextual learning supported by Photomath across different levels of logical-mathematical intelligence are not statistically significant. These results may be related to the structured learning experience provided to students, although such an explanation must be interpreted with caution because the absence of a significant interaction does not prove that all students benefited from the intervention to the same extent. Further research with a larger sample, a longer intervention, and measurements of different individual student characteristics is needed to test whether the moderating role of logical-mathematical intelligence becomes clearer under different learning conditions.

The findings of this study have several implications for mathematics education. Contextual learning supported by Photomath can be considered an alternative approach to providing students with meaningful problem-solving experiences while utilizing digital technology as a supporting resource. However, the use of Photomath must be accompanied by teacher guidance so that students do not merely rely on automatically generated answers but are encouraged to check, interpret, and evaluate their solution steps. This consideration is important because recent research has identified both the potential benefits and limitations of Photomath in mathematic learning (Imaniyah et al., 2025) reported that Photomath can support students' mathematical problem-solving but also noted the potential risk of students becoming dependent on technology and reducing their analytical engagement if its use is not properly guided. Similarly, recent research on students' use of Photomath shows that the app can help students understand problem-solving methods and check their work, but students may also have difficulty interpreting the automatically generated solutions. Therefore, Photomath's contribution in this study should be understood as a complement to contextual learning strategies, not as a substitute for students' reasoning processes. Nevertheless, this study was conducted with a relatively limited sample and within a specific learning context; thus, these findings should not be generalized beyond similar conditions without further evidence. Future research could involve larger and more diverse samples, longer intervention periods, and different mathematical topics to test the consistency of these findings. Further research could also investigate how guided use of Photomath affects students' ability to critically evaluate mathematical solutions, rather than merely obtaining the correct answer.

CONCLUSION AND SUGGESTIONS

Based on the results of the study conducted using a two-way Anava, it can be concluded that contextual learning supported by Photomath has a significant impact on students' reasoning ability. This indicates that the implementation of contextual learning supported by technology can help students develop their mathematical reasoning skills. However, within the design framework and measurement conditions of this study, no statistically significant evidence was found regarding a moderating effect of logical-mathematical intelligence on the relationships between teaching approaches and students' mathematical reasoning.

Based on the research findings, contextual learning supported by Photomath can be considered an alternative approach to fostering students' mathematical reasoning. The use of Photomath should be guided by teachers so that students utilize the app to understand mathematical concepts and develop their reasoning, rather than simply obtaining answers. Future research is recommended to employ a stronger research design, a larger sample size, and a longer intervention period to further examine the impact of context-based learning supported by Photomath on students' mathematical reasoning. Subsequent studies should also continue to use validated instruments and appropriate statistical analyses that account for students' baseline conditions. Further research could explore other student-related factors, such as learning motivation, learning styles, or self-regulated learning, to provide additional perspective on students' learning processes.

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