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Effects of the Picture and Picture Learning Model on Students' Conceptual Understanding and Mathematics Achievement

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ABSTRAK

Penelitian ini bertujuan untuk mengkaji pengaruh model pembelajaran Picture and Picture terhadap pemahaman konseptual dan prestasi belajar matematika peserta didik. Penelitian ini menggunakan pendekatan kuantitatif dengan desain kuasi-eksperimen post-test only control group. Subjek penelitian terdiri atas 58 peserta didik kelas VIII yang dibagi ke dalam kelompok eksperimen dan kelompok kontrol. Data dikumpulkan melalui tes uraian untuk mengukur pemahaman konseptual dan prestasi belajar matematika. Data dianalisis menggunakan one-way Multivariate Analysis of Variance (MANOVA). Hasil penelitian menunjukkan adanya perbedaan multivariat yang signifikan antara kedua kelompok, dengan peserta didik pada kelompok eksperimen memperoleh skor pemahaman konseptual dan prestasi belajar matematika yang lebih tinggi dibandingkan kelompok kontrol. Temuan ini menunjukkan bahwa penggunaan gambar berurutan secara terstruktur dalam model pembelajaran Picture and Picture mampu meningkatkan pemahaman konseptual sekaligus mendukung peningkatan prestasi belajar matematika peserta didik pada jenjang Sekolah Menengah Pertama.

Kata Kunci: Pemahaman Konseptual; Matematika SMP; Prestasi Belajar Matematika; Model Pembelajaran Picture and Picture; Pembelajaran Berbasis Visual.

ABSTRACT

This study aimed to examine the effect of the Picture and Picture learning model on students' conceptual understanding and mathematics achievement. A quantitative approach was employed using a quasi-experimental post-test only control group design. The participants consisted of 58 eighth-grade students divided into an experimental group and a control group. Data were collected through open-ended test items designed to assess conceptual understanding and mathematics achievement. The data were analyzed using one-way Multivariate Analysis of Variance (MANOVA). The results revealed a significant multivariate difference between the two groups, with students in the experimental group achieving higher scores in both conceptual understanding and mathematics achievement than those in the control group. These findings indicate that the structured use of sequential images in the Picture and Picture learning model supports students in organizing mathematical ideas and contributes to improved mathematics achievement at the junior high school level.

Keywords: Conceptual Understanding; Junior High School Mathematics; Mathematics Achievement; Picture and Picture Learning Model; Visual-Based Learning.

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1. INTRODUCTION

Mathematics is widely recognized as a key discipline that supports the development of students' reasoning, analytical skills, and capacity to solve problems. At the junior high school level, mathematics learning is expected to emphasize conceptual understanding rather than mere memorization of formulas, as conceptual mastery enables students to identify relationships among mathematical ideas and apply reasoning meaningfully across contexts (Amo-Asante & Bonyah, 2023; Embong et al., 2019). Conceptual understanding is therefore regarded as a core component of deep and meaningful mathematics learning and has been shown to have a strong relationship with students' mathematics achievement and long-term retention (Saepuloh, Luritawaty, & Afriansyah, 2024; Yuliandari & Anggraini, 2021).

Despite these expectations, empirical evidence indicates that a substantial proportion of students at the lower secondary level continue to face difficulties in attaining adequate conceptual understanding and satisfactory achievement in mathematics. Studies report that more than 60% of junior high school students are unable to explain mathematical concepts in their own words and perform poorly on non-routine problem-solving tasks, indicating weak conceptual understanding and low mathematics achievement (Mukti & Pratiwi, 2025; Afriansyah et al., 2024; Kurniawan et al., 2023; Shawan et al., 2021).

At a broader level, a cross-national analysis of mathematics textbooks from 12 countries revealed that approximately 79% of learning tasks could be completed using memorized procedures, with limited opportunities for conceptual reasoning (Suherman & Elsyifa, 2024; Auliya' & Widjajanti, 2023; Jonsson et al., 2022). Similarly, a study involving Form Two students in Malaysia found that students experienced significant difficulty in understanding abstract and multi-step mathematical problems when instruction relied heavily on procedural and textbook-centered approaches, resulting in unsatisfactory learning outcomes (Embong et al., 2019). According to the findings, inadequate conceptual understanding persists as an important factor influencing low mathematics achievement among Indonesian junior secondary school students.

Junior high school students are a particularly important group in this context, as they are transitioning into a developmental stage where abstract thinking begins to emerge, while still requiring concrete and visual support to construct mathematical meaning (Sun & Yang, 2023). Research has consistently shown that learners at this level benefit from visual representations and concrete examples to strengthen conceptual understanding and reduce cognitive load (Latifa et al., 2025; Rif' at et al., 2024). Visualization, understood as a cognitive process that transforms abstract mathematical ideas into mental or physical representations, plays a crucial role in

facilitating comprehension and reasoning. In classroom practice, visualization strategies such as diagrams, sequential images, manipulatives, and graphical representations function as essential tools for supporting mathematical sense-making (Radzi & Mahmud, 2023). From a Piagetian perspective, learning is most effective when students are provided with opportunities to observe and manipulate representations before formalizing them symbolically (Alias et al., 2024).

A growing body of research has demonstrated that visual and interactive learning approaches are effective in improving students' conceptual understanding and mathematics achievement (Puspitasari & Sari, 2024; Rif' at et al., 2024; Temaj et al., 2025). One instructional approach that aligns closely with these characteristics is the Picture and Picture learning model. According to Yusal et al. (2022), the Picture and Picture learning model is grounded in constructivist learning theory and emphasizes the use of sequential images that students actively arrange, analyze, and explain to construct understanding.

The Picture and Picture learning model employed in this study is based on the framework developed by Yusal et al. (2022), emphasizing the role of logically ordered images in facilitating students' visual reasoning, conceptual connections, and collaborative learning. This process supports the integration of visual and verbal information, which enhances conceptual comprehension and retention (Maulandani & Afriansyah, 2024; Khalil et al., 2024). Through image sequencing and discussion, students are encouraged to identify relationships among concepts, articulate reasoning, and engage in higher-order thinking processes that directly contribute to improved mathematics achievement.

In addition to enhancing cognitive processes, the Picture and Picture learning model contributes to a dynamic and participatory classroom environment. According to Vygotsky (Khalil et al., 2024), learning occurs most effectively through social interaction and collaborative meaning-making. The collaborative activities embedded in the Picture and Picture model support active participation, sustained attention, and positive learning experiences, all of which are essential for maintaining students' motivation during mathematics learning. Increased motivation has been widely recognized as an important factor influencing students' persistence and achievement in mathematics (Rif' at et al., 2024).

Empirical research in the Indonesian context has demonstrated favorable results from the implementation of the Picture and Picture learning model, especially with regard to students' conceptual understanding and mathematics performance. Findings from a quasi-experimental study applying Multivariate Analysis of Variance indicated that students exposed to the Picture and Picture learning model demonstrated superior performance relative to peers receiving conventional instruction across multiple domains, such as learning motivation, mathematical communication, and mathematics achievement (Haerunnisa et al., 2024). Similarly, classroom-based research showed that integrating the Picture and Picture model with

card media increased students' mathematics mastery from 60% to 87%, indicating substantial improvements in learning achievement (Bulu & Agustin, 2025). However, many existing studies emphasize affective outcomes or rely on classroom action research designs, providing limited empirical evidence on the model's contribution to deep cognitive learning outcomes.

Although previous studies have highlighted the potential of the Picture and Picture learning model, research examining its simultaneous effects on both conceptual understanding and mathematics achievement at the junior high school level remains limited. In particular, much of the existing literature relies on classroom action research designs or focuses on single learning outcomes, resulting in relatively little empirical evidence that examines cognitive outcomes concurrently using multivariate approaches. Accordingly, additional research is required to explore the ways in which the Picture and Picture learning model facilitates students' conceptual understanding by enabling them to structure, relate, and interpret mathematical ideas through systematic visual sequencing, while also improving mathematics achievement through active participation, reasoning, and meaningful problem-solving activities.

Based on these considerations, the present study aims to examine the effects of the Picture and Picture learning model on students' conceptual understanding and mathematics achievement using a quasi-experimental design and multivariate analysis. This study is guided by the theoretical perspective that visual representation and structured interaction support deep learning by facilitating cognitive organization and conceptual reasoning. Based on these considerations, this study addresses the following research questions:

1) Do students who are taught using the Picture and Picture learning model demonstrate significantly different levels of conceptual understanding compared to students receiving conventional instruction?
2) Do students taught through the Picture and Picture learning model show significantly different mathematics achievement than those taught using traditional instructional approaches?

2. METHOD

This research employed a quantitative approach using a quasi-experimental design with a posttest-only control group. As random assignment at the individual student level was not possible, existing classes assigned by the school were utilized. The experimental group was instructed in mathematics through the Picture and Picture learning model, whereas the control group received instruction through conventional teaching approaches. Following the intervention, both groups completed the same post-test to assess learning outcomes. An overview of the research design is provided in Table 1.

Table 1. Structure of The Research Design

Group	Randomization	Treatment	Post-test
Experimental	R_1	X	O_1
Control	R_2	–	O_2

Notes:
R_1 and R_2 refer to the use of intact classes without individual randomization; X represents the Picture and Picture instructional treatment; O_1 and O_2 indicate the post-test results of the experimental and control groups.

This design was selected to examine differences in students' conceptual understanding and mathematics achievement between groups instructed using the Picture and Picture learning model and those taught through conventional instructional approaches.

The research was carried out at a junior secondary school in West Java Province during an ongoing academic semester. Two intact Grade VIII classes were chosen using purposive sampling based on comparable academic characteristics, class availability, and alignment with the school timetable. Each class comprised 29 students aged 13 – 14 years. All participants were officially enrolled in the selected classes, attended the instructional sessions, and completed the post-test. Students who were absent during the post-test were excluded from the analysis. Gender data were not collected in this study.

Two open-ended test instruments were used to measure students' learning outcomes. Conceptual understanding was assessed using seven open-ended items on the topic of quadrilaterals, administered over 80 minutes with a maximum possible score of 100. This instrument was developed based on indicators recommended by the National Council of Teachers of Mathematics (NCTM), including the ability to define concepts verbally and in writing, identify examples and non-examples, compare related concepts, identify properties and defining conditions, translate among representations, and apply concepts in problem-solving contexts (Haji, 2019). Mathematics achievement was measured using three open-ended items, also administered within 80 minutes and scored on a maximum of 100. The achievement test was developed based on Bloom's Taxonomy, focusing on the cognitive levels of understanding (C2), application (C3), and analysis (C4), with indicators related to identifying geometric elements, calculating surface area, and calculating volume within contextual problem-solving situations (Soozandehfar & Adeli, 2017).

Student responses to both instruments were evaluated using analytic scoring rubrics aligned with the respective indicators. Item scores were aggregated to obtain composite scores for conceptual understanding and mathematics achievement. Prior to implementation, the instruments were pilot tested to examine item clarity, difficulty level, discrimination index, and overall reliability.

Building on the research design, participants, and instruments described above, the study was implemented through a structured and chronological procedure conducted in four main stages. The preparation stage involved collaborative review of lesson plans and learning materials by the teacher and researcher, as well as finalization of the research instruments following pilot testing. During the implementation phase, the experimental group received mathematics instruction based on the Picture and Picture learning model, where lesson-related images were introduced in an ordered manner. Students were directed to observe, analyze, and logically sequence the images, participate in discussion, and articulate the reasoning behind their arrangements, after which the teacher provided clarification and reinforced the targeted concepts (Khalil et al., 2024; Yusal et al., 2022).

In contrast, the control group received conventional instruction consisting primarily of teacher explanation, worked examples, and individual practice, with equivalent topic coverage and instructional time. Classroom observations were conducted throughout the implementation to document teaching practices and student engagement, and both groups were taught under natural classroom conditions to maintain ecological validity.

After the instructional sessions were completed, both groups were given a posttest to assess students' conceptual understanding and mathematics achievement. To ensure data integrity and confidentiality, student responses were coded using anonymized identifiers and stored securely for research purposes only.

The data obtained were analyzed using IBM SPSS Statistics. A one-way Multivariate Analysis of Variance (MANOVA) was conducted to assess the combined effects of the instructional model on students' conceptual understanding and mathematics achievement, as this method is suitable for examining multiple dependent variables simultaneously (Akbay et al., 2019). Prior to conducting MANOVA, all relevant statistical assumptions were tested, including multivariate normality, homogeneity of variance – covariance matrices using Box's M test, and linearity, in accordance with established guidelines (Boncales, 2025). Once the required assumptions had been satisfied, MANOVA was conducted at a significance level of $\alpha = 0.05$, and the magnitude of the instructional model's effects was quantified using partial eta squared as the effect size measure.

Ethical considerations were observed throughout the study. Permission was obtained from the school administration, and informed consent was secured from the participating mathematics teacher. Students were fully informed about the objectives of the study and their right to discontinue participation at any stage without academic repercussions. Confidentiality was maintained through the use of anonymized data codes, and all research procedures were conducted in accordance with established ethical guidelines for educational research.

3. RESULT AND DISCUSSION

This section outlines the results and discussion of the study. The findings are presented first to summarize the outcomes of the data analysis, followed by a discussion that interprets the results in relation to the research objectives, relevant theoretical frameworks, and prior research.

a. Results

This section presents the study results in accordance with the order of the statistical procedures performed. The reported findings encompass descriptive statistics, tests of assumptions, multivariate analysis, and subsequent univariate analyses to investigate differences in students' mathematics achievement and conceptual understanding between the experimental and control groups. Table 2 presents descriptive statistics summarizing students' mathematics achievement and conceptual understanding scores for both instructional groups.

Table 2. Descriptive Statistics for Mathematics Achievement and Conseptual Understanding

Descriptive Statistics	Mathematics Achievement		Conceptual Understanding	
	Experimental	Control	Experimental	Control
N	29	29	29	29
Mean	73.14	62.48	54.5	43.12
SD	7.66	5.87	7.89	11.97
Min	61	50	45	25
Max	92	75	70	60

The results show that students in the experimental group achieved higher mean scores than those in the control group on both variables. In terms of mathematics achievement, the experimental group recorded a mean score of 73.14 (SD = 7.66), whereas the control group obtained a lower mean of 62.48 (SD = 5.87). A similar pattern was observed for conceptual understanding, with the experimental group achieving a mean score of 54.50 (SD = 7.89), compared to 43.12 (SD = 11.97) in the control group. The observed minimum and maximum score ranges further suggest that students in the experimental group exhibited higher and more consistent performance across both measures.

Before conducting multivariate analysis, assumption tests were performed to ensure the appropriateness of the data. The homogeneity of variance – covariance matrices was evaluated using Box' s M test, and the results confirmed that this assumption was satisfied. Data normality was examined through the Shapiro – Wilk test, indicating that scores for both mathematics achievement and conceptual understanding followed a normal distribution. As all underlying assumptions were met, the data were considered appropriate for subsequent multivariate analysis.

Subsequently, a one-way Multivariate Analysis of Variance (MANOVA) was performed to investigate the combined effect of the instructional model on students' mathematics

achievement and conceptual understanding. The multivariate results shown in Table 3 indicated a statistically significant difference between the experimental and control groups, as reflected by a Pillai' s Trace value of 0.559, $F(2, 55) = 34.854$, $p < .001$. Comparable significance levels were also found for Wilks' Lambda, Hotelling' s Trace, and Roy' s Largest Root, all of which confirmed a significant multivariate impact of the instructional model on the joint dependent variables.

Table 3. Multivariate Tests for Mathematics Achievement and Conceptual Understanding

Statistic	Value	F	Sig
Pillai' s Trace	0.559	34.854	< .001
Wilks' Lambda	0.441	34.854	< .001
Hotelling' s Trace	1.267	34.854	< .001
Roy' s Largest Root	1.267	34.854	< .001

After the multivariate analysis yielded significant results, follow-up univariate analyses were conducted to assess the effect of the instructional model on each dependent variable individually. As shown in Table 4, a significant difference in mathematics achievement was observed between the groups, $F(1, 56) = 34.110$, $p < .001$, with a partial eta squared value of 0.379. Similarly, conceptual understanding also differed significantly between groups, $F(1, 56) = 27.312$, $p < .001$, with a partial eta squared of 0.328. These results indicate that the instructional model explained a considerable proportion of variance in both outcome measures.

Table 4. Tests of Between-Subjects Effects

Dependent Variable	F	Sig	Partial Eta Squared
Mathematics Achievement	34.110	< .001	0.379
Conceptual Understanding	27.312	< .001	0.328

b. Discussions

Overall, the results of this study demonstrate that the Picture and Picture learning model exerts a significant and simultaneous effect on students' conceptual understanding and mathematics achievement. The multivariate findings reveal that differences between the experimental and control groups occurred concurrently across both learning outcomes, underscoring the contribution of this research. Unlike many prior studies that have examined learning outcomes in isolation, this study provides empirical evidence that the Picture and Picture learning model is capable of influencing multiple cognitive outcomes at the same time, thereby reinforcing its relevance for mathematics instruction at the junior secondary level.

The concurrent gains in conceptual understanding and mathematics achievement may be attributed to the unique characteristics of the Picture and Picture learning model, which was applied in a consistent and systematic manner throughout the instructional process. The model

emphasizes structured visual sequencing, active student engagement, and verbal explanation of reasoning.

These features align closely with theories of meaningful learning, which emphasize that learning is most effective when students actively organize information, construct meaning, and articulate their understanding (Leyson & Andrino, 2025; Yuliandari & Anggraini, 2021). By encouraging students to observe, arrange, and explain sequences of images, the Picture and Picture model supports cognitive organization and conceptual construction while reducing students' reliance on procedural memorization (Radzi & Mahmud, 2023; Rif' at et al., 2024). This instructional mechanism provides an explanation for why students in the experimental group demonstrated superior performance not only on achievement-oriented tasks but also on tasks that required deeper levels of conceptual reasoning (Temaj et al., 2025).

The univariate findings further support this interpretation, as reflected in the substantial effect sizes observed for both outcome variables. These findings indicate that the Picture and Picture learning model supports learning processes that extend beyond mere surface-level procedural performance. Students who experienced this model were more capable of connecting multiple representations, recognizing relationships among mathematical concepts, and applying their understanding in problem-solving situations. Such outcomes are consistent with the view that conceptual understanding serves as a critical foundation for sustainable mathematics achievement (Leyson & Andrino, 2025; Yuliandari & Anggraini, 2021).

From a theoretical perspective, the effectiveness of the Picture and Picture learning model can be understood through theories of visual representation and cognitive processing in mathematics learning. Visual-based instruction plays an important role in reducing cognitive load and supporting the transition from concrete representations to abstract reasoning, especially for junior high school students who are still developing formal operational thinking skills (Sun & Yang, 2023; Temaj et al., 2025). The use of sequential images in the Picture and Picture model functions as cognitive scaffolding, helping students organize information logically and build coherent mental representations of mathematical concepts (Radzi & Mahmud, 2023; Rif' at et al., 2024).

Beyond its visual dimension, the Picture and Picture learning model also incorporates structured interaction that aligns with socio-constructivist perspectives emphasizing learning through social interaction and collaborative meaning-making. When students are encouraged to discuss, justify, and explain image sequences, they actively externalize their thinking, negotiate meaning with peers, and refine their understanding through dialogue. These interactive processes are central to the development of higher-order thinking and conceptual reasoning, as highlighted in constructivist learning theory (Khalil et al., 2024). This theoretical alignment helps

explain why the model was able to produce simultaneous gains in both conceptual understanding and mathematics achievement.

The results of this study align with and build upon previous empirical research on visual and collaborative instructional strategies. Earlier studies have demonstrated that the integration of visual representations and student interaction has a positive effect on mathematics learning outcomes (Herrera et al., 2024; Ruamba et al., 2025). Further research emphasizes the role of students' visual abilities in facilitating conceptual representation and enhancing problem-solving performance (Rif' at et al., 2024), as well as the effectiveness of structured visual strategies in improving students' ability to interpret and solve mathematical problems (Radzi & Mahmud, 2023). Building on this body of work, the present study demonstrates that the Picture and Picture learning model does not merely enhance isolated aspects of learning but produces a combined and simultaneous effect on multiple cognitive outcomes when implemented with strong instructional fidelity.

Collectively, these results indicate that the effectiveness of the Picture and Picture learning model stems from its capacity to combine visual representations, structured interaction, and logical reasoning within a unified instructional framework. When implemented as intended, the model creates learning environments that support students' construction of mathematical meaning while simultaneously improving achievement outcomes. This combined effect underscores the potential of the Picture and Picture learning model as an effective instructional approach for mathematics at the junior secondary level, particularly within educational settings that prioritize deep, meaningful, and concept-focused learning in accordance with the objectives of the Merdeka Curriculum.

4. CONCLUSION

This study examined the effects of the Picture and Picture learning model on junior high school students' conceptual understanding and mathematics achievement. The findings show that students taught using the Picture and Picture model achieved significantly higher levels of conceptual understanding and mathematics achievement than those who received conventional instruction, thereby addressing both research questions of the study.

These results indicate that the use of structured and sequential visual representations supports students in organizing mathematical ideas, identifying conceptual relationships, and engaging more actively in the learning process. From a practical perspective, the Picture and Picture learning model offers a viable instructional alternative for promoting meaningful and concept-oriented mathematics learning in alignment with the principles of the Merdeka Curriculum.

This study is subject to several limitations, including the use of a post-test-only quasi-experimental design and a limited sample from a single school. Future research is therefore recommended to employ pretest – posttest designs, involve more diverse samples, and incorporate qualitative approaches to further explore students' learning processes when using the Picture and Picture learning model.

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