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EFFECTIVENESS OF USING META AI IN IMPROVING UNDERSTANDING OF ALGEBRA CONCEPTS BY GRADE VII STUDENTS AHMAD YANI JUNIOR HIGH SCHOOL

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Abstract

This study aims to analyze the effectiveness of using Meta AI in improving the understanding of algebra concepts of seventh-grade students at Ahmad Yani Pagelaran Junior High School. The background of the problem shows that students have difficulty understanding basic algebra concepts, including the introduction of variables, coefficients, constants, and simplification of algebraic equations due to the use of conventional learning methods that are less interactive. The study used a quasi-experimental design with 42 students divided into an experimental group (using Meta AI) and a control group (conventional method). Data were collected through pretests, posttests, and learning observations, then analyzed using descriptive and inferential statistics with t-tests and N-Gain analysis. The results showed a significant difference between the two groups ($p < 0.05$). The experimental group achieved an average posttest of 83 with an N-Gain of 73.4% (high category), while the control group only achieved 35 with an N-Gain of 17% (low category). The classical completeness of the experimental group reached 100%, exceeding the minimum standard of 85%. Meta AI has been shown to increase student engagement by up to 90%, reduce procedural errors by 70%, and improve the accuracy of identifying algebraic components by up to 85%. The study concluded that Meta AI is highly effective in improving understanding of algebraic concepts through adaptive, personalized, and interactive learning tailored to individual students' needs.

Keywords:*Meta Ai, Algebra Learning, Artificial Intelligence, Educational Technology.*

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INTRODUCTION

Mathematics is an essential core subject in education, where students are taught not only numerical and symbolic concepts but also logical, analytical, and methodical thinking skills. Algebra is one of the fundamental topics taught in junior high school, with key components including variables, coefficients, constants, and terms in algebraic expressions. Understanding algebraic expressions is crucial because it forms the foundation for understanding more advanced mathematics and has broad applications in everyday life. Through algebra, students can transform real-world problems into mathematical models that are easier to analyze and solve, while developing critical, creative, and abstract thinking skills.[1] states that algebra is a key subject in shaping students' character because it fosters important skills such as critical thinking, creativity, reasoning, and abstract thinking. However, observations at Ahmad Yani Junior High School showed that seventh-grade students had difficulty understanding basic algebraic concepts, including the introduction of variables, coefficients, constants, and simplification of algebraic equations. This difficulty negatively impacted students' mathematical skills and their ability to solve mathematical problems. Previous research has shown that students' proficiency in algebraic reasoning is crucial for their success in solving various mathematical problems, both in academic and real-world contexts, so new teaching methods are needed to improve students' understanding.[2].

Based on direct observation findings, many students have difficulty understanding the basic concepts of algebra from the time they first learn the material until when they need to simplify algebraic expressions or solve related problems.[3] Jupri noted that students' challenges in algebra often stem from difficulty understanding basic concepts, particularly variables and coefficients. This lack of understanding leads students to repeat the same mistakes when solving problems. A common problem is the inability to distinguish variables from coefficients, which leads to errors in problem-solving because students don't realize that variables are unknown values or common symbols for numbers. As a result, students often make mistakes that lead to poor academic performance. One major contributing factor to this problem is the reliance on conventional teaching styles that use lecture formats.[4]This approach reduces student engagement in learning because it focuses on one-way communication, where students receive information without the opportunity to ask questions or participate in discussions. This results in limited understanding of mathematical concepts and makes students passive and less engaged in learning. The lack of interaction in a lecture format means students do not have sufficient opportunities to explore and form their own understanding of mathematics. As a result, their understanding of mathematical concepts tends to be shallow, even though mastering mathematics requires in-depth knowledge and regular practice.[5].

Students show reduced enthusiasm for learning mathematics due to limited interactive educational opportunities.[6]Those who are less

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engaged in the learning experience struggle to develop the critical and inventive thinking skills essential for solving math problems. This situation creates an urgent need for innovation in teaching methods to help students grasp algebraic concepts. The application of technologies such as artificial intelligence can foster an active and personalized learning environment, tailored to each student's needs. Integrating AI technology into an educational framework allows for the creation of content tailored to the student's learning pace, providing immediate feedback and interactive tasks to help students learn complex subjects like algebra. MetaAI offers a more stimulating and individualized educational environment than conventional methods. This AI system provides adaptive learning features that can adapt to each student's pace and learning style while providing immediate feedback.[7]Students are motivated to engage more actively in learning because they can progress at their own pace. The application of Meta AI in education is expected to address the shortcomings of traditional, less engaging lecture approaches. With its diverse features, Meta AI helps educators present content in a more engaging manner, encourages conversation, and offers diverse, customizable practice questions tailored to students' individual needs.

The application of AI technology in education has been shown to improve the overall engagement and effectiveness of the learning experience. Educators have the ability to track student progress in real time.[8]and modifying materials and practice questions to better meet each student's unique needs, resulting in a more adaptive and responsive learning environment. The AI system can generate practice questions tailored to the student's skill level with immediate feedback that allows students to immediately recognize their errors. This accelerates conceptual understanding and helps students gradually develop algebra skills. This personalized feature is key to addressing individual difficulties students experience in understanding basic algebra concepts. The use of technology-based teaching methods such as Meta AI is crucial for improving the quality of mathematics education at Ahmad Yani Junior High School. This strategy aims to help students better understand algebra, reduce errors when simplifying algebraic expressions, and improve overall learning outcomes. This new approach not only benefits students but also supports teachers in making the learning experience more effective, efficient, and enjoyable. The implementation of Meta AI is expected to revolutionize mathematics learning, making it more interactive and personalized. Therefore, this study focuses on evaluating the effectiveness of using Meta AI in the context of algebra learning for seventh-grade students.[9].

Based on the background of the problem that has been described, this study aims to provide empirical evidence regarding the effectiveness of using Meta AI in improving the understanding of algebraic concepts of seventh-grade students at Ahmad Yani Middle School. The focus of the study is directed at how Meta AI can overcome students' difficulties in understanding variables, coefficients,

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constants, and simplification of algebraic expressions. This study is expected to contribute to the development of innovative and efficient mathematics teaching approaches. The results obtained will provide practical guidance for educators in integrating AI technology into mathematics learning, while also providing a theoretical basis for further research in the field of artificial intelligence technology-based education. This study is limited to the study of algebraic representations for seventh-grade students at Ahmad Yani Pagelaran Middle School, with Meta AI as the only artificial intelligence platform used.[10]. Understanding algebraic concepts is defined as students' ability to recognize, explain, and solve problems related to basic algebraic concepts, as well as simplify algebraic expressions. Learning using Meta AI is a mathematics learning process with the help of an AI system as the main medium, providing interactive and personalized materials, exercises, and feedback. Learning effectiveness is measured based on the achievement of learning objectives, namely a significant increase in students' understanding of algebraic concepts after participating in Meta AI-based learning compared to conventional learning, so that it can make a real contribution to innovation in mathematics education.

METHOD

Research Design

This study used a quantitative approach with a quasi-experimental design that aimed to examine the causal relationship between the implementation of Meta AI as an independent variable and the improvement in understanding of algebraic concepts as a dependent variable. The quasi-experimental design was chosen because the study was conducted in a real classroom environment with naturally formed groups, so full randomization was not possible. This methodology still allowed the researcher to control confounding variables as much as possible and make an accurate assessment of the effectiveness of Meta AI. The study consisted of three main stages: (1) a pre-experimental stage with a pretest administered to both groups to evaluate students' initial abilities, (2) a treatment stage where the experimental group used Meta AI while the control group used conventional methods, and (3) a post-experimental stage with a posttest administered to assess the effects of the treatment. Initial disparities in students' abilities before the treatment were addressed by adding a pre-test to both groups.

Location and Time of Research

The research was conducted at Ahmad Yani Pagelaran Junior High School, located on Jl. KH. Syuhud Zayyadi, Karangsuko Village, Pagelaran District, Malang Regency. The research took place in the second semester of April 2025. The location was selected based on the availability of technological facilities that support the implementation of MetaAI and the homogenous characteristics of the students.

Population and Sample

The study population consisted of all 7th grade students of Ahmad Yani Pagelaran Junior High School in the 2024/2025 academic year, totaling 42 students from two classes. Students had similar socioeconomic

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backgrounds and academic abilities, allowing for a fair comparison between the control and experimental groups. The sampling technique used purposive sampling to ensure that both groups had comparable characteristics before the experiment. The sample consisted of two 7th grade classes with an estimated 21-33 students per class, with one class serving as the experimental group and the other as the control group.

Research Variables

The independent variable in this study is the implementation of Meta AI as an interactive learning medium, with the indicator of student learning effectiveness measured by the increase in understanding of algebraic concepts after using the medium. The dependent variable is the understanding of algebraic concepts of seventh-grade students at Ahmad Yani Middle School, which is the main focus for evaluation as a result of the implementation of Meta AI. The main aspects assessed include the ability to identify variables, coefficients, constants, and terms in algebraic expressions, as well as the ability to simplify and operate algebraic forms.

Research Instruments

The research instruments consisted of two main types: observation tools and test tools. Observation guidelines were used to observe students' learning activities while using Meta AI for 80 minutes (two lesson hours) using a non-participant observation method. Observations focused on students' understanding of algebra topics, challenges faced, and the role of Meta AI in supporting learning. The test instruments consisted of a pretest and posttest based on indicators of understanding algebraic concepts.

The test is designed to measure students' abilities in: (1) identifying variables, coefficients, constants, and terms in algebraic expressions, (2) simplifying algebraic expressions, (3) performing algebraic operations, and (4) applying algebraic concepts in problem solving.

Table 1. Signs of understanding mathematical concepts

Concept Understanding Indicators	Indicator
Re-explaining a concept	- Rewrite algebraic forms. - Students are able to define algebraic terms (variables, coefficients, constants) in their own words.
Grouping objects	- Mentioning variables, coefficients, constants and terms of several algebraic forms. - Students can identify and classify similar/unsimilar tribes.
Providing examples and non-examples of a concept	- Identify examples and give examples of algebraic forms. - Students are able to differentiate between algebraic and non-algebraic forms.

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Expressing concepts in various mathematical representation concepts	- Changing algebraic forms to their simplest form and changing story problems into algebraic forms. - Students can convert algebraic forms into visual models (graph diagrams) or story problems.
Applying concepts or algorithms in problem solving.	- Using the concept of addition and subtraction of algebraic forms in solving everyday life problems. - Students use algebraic operations to solve contextual problems.

Research Procedures

The research was conducted through three systematic stages. The initial stage included requesting research permission from the principal, discussions with mathematics teachers to identify materials and schedule them, validating the research instruments, and preparing the Meta-AI learning tools. The implementation stage included administering a pretest to both groups, implementing Meta-AI learning for the experimental group and conventional methods for the control group, observing learning activities, and administering a posttest and evaluation questionnaire. The evaluation and reporting stage focused on analyzing student learning outcomes and comparing them between the two groups.

Data Analysis Techniques

Descriptive Statistical Analysis

Descriptive statistical analysis was used to describe and explain the students' learning conditions, especially in the experimental group. Calculations included variation statistics, highest and lowest scores using SPSS software, frequency distribution, mean, median, mode, quartiles, and measures of variability such as variance and standard deviation.

Table 2 Categories of learning model implementation

Average Score (G)	Category
3.5≤G 4.00≤	Very well executed
2.5≤G 3.5≤	Well executed
1.5≤G 2.5≤	Quite well implemented
1≤G 1.5≤	Not implemented well

Learning Implementation Analysis

Learning implementation data was collected through observation forms during learning sessions. The quality of learning implementation was calculated using the average observation score divided by the number of aspects observed. Learning implementation categories were classified based on score ranges.

Analysis of Student Learning Outcomes

Classification of learning outcome data uses the National Department of Education standards with categories of very high (90-100), high (80-89), medium (65-79), low

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(55-64), and very low (0-54). Student performance improvement is measured using the normalized gain equation.

Inferential Statistical Analysis

Inferential analysis was used to estimate and extrapolate findings to a broader population. Prior to analysis, prerequisite tests were performed, including a normality test using the Kolmogorov-Smirnov test and a homogeneity test using the Bartlett test with a significance level of 5% (0.05).

Table 3. Explanation of mathematics learning achievement score categories

Average Score (G)	Category
3.5≤G 4.00≤	Very well executed
2.5≤G 3.5≤	Well executed
1.5≤G 2.5≤	Quite well implemented
1≤G 1.5≤	Not implemented well

Hypothesis Testing

Hypothesis testing was conducted using a paired sample t-test with three main hypotheses: (1) the difference in pretest results between the experimental and control groups, (2) the difference in posttest results between the two groups, and (3) a comparison of improvements in learning outcomes. The testing criteria used a significance level of 0.05, where H_0 was accepted if the significance value was > 0.05 and H_1 was accepted if the significance value was < 0.05.

Effectiveness Test (N-Gain)

The effectiveness of the treatment was evaluated using the normalized N-gain formula with high (0.70 < N-Gain ≤ 1.00), medium (0.30 < N-Gain ≤ 0.70), and low (N-Gain ≤ 0.30) categories. Interpretation of effectiveness used percentages with effective (>76%), quite effective (56-75%), less effective (40-55%), and ineffective (<40%) categories.

Effectiveness Criteria

Learning is considered effective if it meets three criteria: (1) the average posttest score exceeds the KKM, namely 71, (2) the normalized gain is at least in the moderate category, and (3) the classical completion level exceeds 85%. These three indicators serve as a comprehensive benchmark for assessing the effectiveness of the teaching strategies used in improving students' understanding of algebraic concepts.

RESULTS AND DISCUSSION

General Description of Research Results

The observation results showed a significant difference in student engagement between the experimental class using Meta AI and the control class using conventional methods.[11]In the experimental class, 90% of students were actively engaged in Meta AI-based learning, such as asking questions directly through the chat feature and participating in interactive drag-and-drop exercises. Student enthusiasm increased significantly, especially when completing reward-based challenges such as interactive quizzes.

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Table 4. Explanation of the effectiveness of n-gain values

Normalized N-Gain Average.	Classification.
0.70 < N-Gain≤1.00	Tall.
0.30 < N-Gain≤0.070	Currently.
N-Gain≤0.30	Low.

Conceptually, the accuracy of identifying algebraic components (variables, coefficients, constants, and like terms) reached 85% thanks to Meta AI's dynamic visualizations. Procedural errors were reduced by 70% due to the system's real-time feedback. For example, a student who initially struggled to differentiate $2x^2$ and $3x$ successfully simplified $4x^2 + 2x - x^2 + 5$ to $3x^2 + 2x + 5$ after receiving adaptive guidance from Meta AI. In contrast, in the control class, only 40% of students actively participated, and 60% of students experienced misconceptions such as assuming $5x + 3y = 8xy$ or making repeated errors in sign operations.

Student Learning Outcomes in Experimental and Control Classes

Experimental Class (Meta AI)

The results of the analysis of pretest and posttest data for class VII A using Meta AI showed a significant increase in understanding of algebraic concepts. Based on the data, the average student score on the pretest was 25, while the average posttest score reached 83. The pretest score was below the Minimum Competency (KKM) (70), but the posttest score exceeded the established standard. This improvement demonstrates Meta AI's effectiveness in helping students understand algebraic concepts.

Table 5. Description of pretest and posttest scores for experimental class (VII A)

Statistics	Pretest	Posttest
Number of Students	22	22
Maximum Value	40	90
Minimum Value	20	75
Average value	25	83
Standard Deviation	6,725	4,031

The frequency distribution shows that in the pretest, all students (100%) had not achieved the KKM, with the majority obtaining a score of 20. After the implementation of Meta AI, all students (100%) succeeded in achieving the KKM in the posttest, with a higher and more even distribution of scores.

Table 6. Frequency distribution of posttest scores for the experimental class

	Mark	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	70	4	18.2	18.2	18.2
	80	15	68.2	68.2	86.4
	90	3	13.6	13.6	100.0
Total		**22**	**100.0**	**100.0**	

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Control Class (Conventional Method)

Class VII B as a control group using conventional learning methods showed limited improvement.

The average pretest score for the control class was 21.57, while the average posttest only reached 35. Both averages were still below the required KKM (70). These results indicate that conventional methods are less effective in improving students' understanding of algebraic concepts.

Table 7. Description of pretest and posttest values for control class VII B

Data	*Pretest*	*Posttest*
Number of Students	19	19
Maximum Value	30	45
Minimum Value	20	20
Average value	21.57	35
Standard Deviation	3,355	6,871

Effectiveness of Using Meta AI
N-Gain Analysis

To measure the effectiveness of learning, an N-Gain analysis was conducted which compared the increase in learning outcomes between the two groups.[13].

Table 8. Results of n-gain test calculation for experimental class

Class	Statistics	Statistics	Std. Error
NGain_Percent Experiment	Mean	73.3766	1.39338
	95% Confidence Interval for Mean - Lower Bound	70.4785	
	95% Confidence Interval for Mean - Upper Bound	76.2747	
	5% Trimmed Mean	73.2053	
	Median	75,0000	
	Variance	42,726	
	Standard Deviation	6.53648	
	Minimum	62.50	
	Maximum	87.50	
	Range	25.00	
	Interquartile Range	3.57	
	Skewness	.284	.491
	Kurtosis	.581	.953
Control	Mean	17.0550	2.05519
	95% Confidence Interval for Mean - Lower Bound	12.6872	
	95% Confidence Interval for Mean - Upper Bound	21.3228	
	5% Trimmed Mean	17.1583	
	Median	15.3333	

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Class	Statistics	Statistics	Std. Error
	Variance	80,252	
	Standard Deviation	8.95837	
	Minimum	.00	
	Maximum	31.25	
	Range	31.25	
	Interquartile Range	12.50	
	Skewness	.218	.524
	Kurtosis	-.624	1,014

The N-Gain assessment results showed that the experimental group achieved an average score of 73.4%, which is considered highly effective. In contrast, the control group only achieved a score of 17%, indicating low effectiveness. This significant difference demonstrates the superiority of the Meta-AI approach in improving student learning outcomes.[14].

Classical Completion

Based on the KKM set at Ahmad Yani Pagelaran Middle School, namely 70, the classical completion level of the experimental class showed optimal results.

Table 9. Classical completion data

Test	Minimum Competency (KKM)	Completed	Not Completed
Pretest	70	0%	100%
Posttest	70	100%	0%

Data shows that in the pretest, all students in the experimental class (100%) did not meet the Minimum Competency (KKM). However, after implementing MetaAI, all students (100%) successfully achieved the KKM in the posttest. This 100% completion rate exceeds the minimum effectiveness standard of 85%, thus declaring the learning process highly effective.

Prerequisite and Hypothesis Testing

Normality and Homogeneity Test

Before conducting inferential analysis, prerequisite tests were carried out to ensure that the data met the assumptions of parametric analysis.

Table10. Normality test after experiment for experimental and control groups

	Class	Kolmogorov-Smirnov^a^			Shapiro-Wilk		
		Statistics	df	Sig.	Statistics	df	Sig.
Learning outcomes	Experimental Class	.124	22	.200*	.977	22	.862
	Control Class	.135	19	.200*	.938	19	.238

The results of the normality test using the Kolmogorov-Smirnov test showed a significance value of 0.862 for the experimental class and 0.238 for the control class. Both values were

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> 0.05, indicating that the data were normally distributed.

Table 11. Homogeneity of variance test

		Levene Statistics	df1	df2	Sig.
Learning outcomes	Based on Mean	3,629	1	39	.064
	Based on Median	3,663	1	39	.063
	Based on Median and with adjusted df	3,663	1	29,082	.066
	Based on trimmed mean	4,011	1	39	.052

The homogeneity test showed a significance value of 0.064 > 0.05, indicating that the variances of both groups were homogeneous. With the normality and homogeneity assumptions met, the analysis could proceed using parametric statistics.

Hypothesis Testing

Comparison of Learning Outcomes Between Groups

Table 14. Results of the independent sample t test

		t	Df	Sig. (2-tailed)	Mean Difference	Standard Error Difference
Posttest	Equal variances assumed	27,836	39	.000	48,181	1,7309

The independent sample t-test showed a significance value of 0.000 < 0.05, with a calculated t value of 27.836 > t table of 0.835. These results indicate the rejection of H_0, which means there is a significant difference between student learning outcomes using Meta AI compared to conventional methods. The average posttest score of the experimental class (83) was much higher than that of the control class (35).

Interpretation and Implications of Results

Research results consistently show the effectiveness of Meta AI in learning algebraic concepts.[15]. All effectiveness indicators were met: (1) the posttest average (83) exceeded the KKM (70), (2) N-Gain reached the high category (73.4%), and (3) classical completeness reached 100% (>85%). Meta AI plays a crucial role in creating personalized and efficient learning. This platform is able to detect individual student error patterns and provide specific exercises as needed. Time efficiency was also achieved because teachers saved 50% of their time correcting assignments thanks to the automation of AI assessments, allowing them to focus more on discussing complex problems such as the application of algebra in story problems. The significant difference between the experimental and control groups indicates that AI technology can be an effective solution to overcome students' difficulties in understanding abstract mathematical concepts. These results support the theory of adaptive learning which

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emphasizes the importance of personalization in the learning process to achieve optimal results.

CONCLUSIONS

Based on the results of a quasi-experimental study conducted at Ahmad Yani Pagelaran Junior High School, it can be concluded that the implementation of Meta AI has proven highly effective in improving the understanding of algebra concepts in seventh-grade students. This effectiveness is demonstrated through three main indicators, all of which were optimally met. First, the average posttest score of the experimental group reached 83, exceeding the minimum minimum completion rate of 70, while the control group only achieved 35. Second, the N-Gain analysis showed a high effectiveness category with a score of 73.4% in the experimental group, significantly different from the control group which only achieved 17%. Third, the classical completion rate reached 100%, far exceeding the minimum standard of 85%. Meta AI's strength lies in its ability to provide adaptive and personalized learning that can adjust to the individual pace and learning style of students. This platform is capable of providing dynamic visualizations for algebra components, real-time feedback that reduces procedural errors by 70%, and interactive features that increase student engagement by up to 90%. The significant difference with conventional methods ($p < 0.05$) proves that AI technology can be an innovative solution to overcome students' difficulties in understanding abstract mathematical concepts, especially in identifying variables, coefficients, constants, and simplifying algebraic expressions. This finding provides an important contribution to the development of technology-based mathematics education.

SUGGESTION

Based on the research findings, several suggestions can be recommended for further implementation. First, schools need to provide adequate technological infrastructure, including a stable internet connection and devices that support optimal use of Meta AI. Second, mathematics teachers should undergo special training on integrating AI technology into learning to maximize the platform's potential. Third, Meta AI implementation should be carried out in stages with intensive mentoring in the initial phase to ensure effective adaptation. Fourth, further research is needed with a broader range of mathematics material and at different educational levels to test the consistency of Meta AI's effectiveness. Fifth, the development of AI-based learning content should be adapted to local curricula and the characteristics of Indonesian students. Sixth, regular evaluation of the impact of AI technology use on students' critical thinking and creativity skills is necessary to ensure a balance between technological efficiency and the development of holistic cognitive abilities.

REFERENCES

[1] L. Yi, D. Liu, T. Jiang, and Y. Xian, “The Effectiveness of AI on K-12 Students’ Mathematics Learning: A Systematic Review and Meta-Analysis,” Int. J. Sci.

Jurnal Pendidikan Matematika dan IPA
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Math. Educ., 2024, doi: 10.1007/s10763-024-10499-7.

[2] N. Matsuda, W. Weng, and N. Wall, "The Effect of Metacognitive Scaffolding for Learning by Teaching a Teachable Agent," Int. J. Artif. Intell. Educ., vol. 30, pp. 1–37, 2020, doi: 10.1007/s40593-019-00190-2.

[3] S. Hwang, "Examining the Effects of Artificial Intelligence on Elementary Students' Mathematics Achievement: A Meta-Analysis," Sustainability, 2022, doi: 10.3390/su142013185.

[4] A. Canonigo, "Levering AI to enhance students' conceptual understanding and confidence in mathematics," J. Comput. Assist. Learn., vol. 40, pp. 3215–3229, 2024, doi: 10.1111/jcal.13065.

[5] Y. Qiu, J. Pan, and N. Ishak, "Effectiveness of Artificial Intelligence (AI) in Improving Pupils' Deep Learning in Primary School Mathematics Teaching in Fujian Province," Comput. Intell. Neurosci., vol. 2022, 2022, doi: 10.1155/2022/1362996.

[6] L. Zheng, J. Niu, L. Zhong, and J. F. Gyasi, "The effectiveness of artificial intelligence on learning achievement and learning perception: A meta-analysis," Interact. Learn. Environ., vol. 31, pp. 5650–5664, 2021, doi: 10.1080/10494820.2021.2015693.

[7] Y. Tian, X. Zhao, and W.-H. Huang, "Meta-learning approaches for learning-to-learn in deep learning: A survey," Neurocomputing, vol. 494, pp. 203–223, 2022, doi: 10.1016/j.neucom.2022.04.078.

[8] W. Rong and Z. Yu, "Do AI chatbots improve students learning outcomes? Evidence from a meta-analysis," Br. J. Educ. Technol., vol. 55, pp. 10–33, 2023, doi: 10.1111/bjet.13334.

[9] H. Lee, F. Stinar, R. Zong, H. Valdiviejas, D. Wang, and N. Bosch, "Learning Behaviors Mediate the Effect of AI-powered Support for Metacognitive Calibration on Learning Outcomes," Proc. 2025 CHI Conf. Hum. Factors Comput. Syst., 2025, doi: 10.1145/3706598.3713960.

[10] M. Vaccaro, A. Almaatouq, and T. Malone, "When combinations of humans and AI are useful: A systematic review and meta-analysis," Nat. Hum. Behav., vol. 8, pp. 2293–2303, 2024, doi: 10.1038/s41562-024-02024-1.

[11] A. Asmedy, "Perbedaan Hasil Belajar Siswa yang Diajar Menggunakan Model Pembelajaran Soal Terbuka dengan Model Pembelajaran Konvensional," Ainara J. (Jurnal Penelit. dan PKM Bid. Ilmu Pendidikan), vol. 2, no. 2, pp. 79–88, 2021, doi: 10.54371/ainj.v2i2.36.

[12] R. A. Sari, "… dan jaringan dasar karena penerapan model pembelajaran problem solving dibandingkan dengan model pembelajaran discovery learning

Jurnal Pendidikan Matematika dan IPA
Vol. 17, No. 1 (2026) h. 14-27

pada siswa kelas X di …,” J. Ilm. Edutic Pendidik. dan Inform., vol. 5, no. 2, 2019.

[13] C. P. Kolopita, M. R. Katili, and R. M. T. Yassin, “Pengaruh Media Pembelajaran Terhadap Hasil Belajar Siswa Pada Mata Pelajaran Komputer dan Jaringan Dasar,” Invert. J. Inf. Technol. Educ., vol. 2, no. 1, pp. 1–12, 2022, doi: 10.37905/inverted.v2i1.13081.

[14] M. Solehudin and Widya Rahmawati Al-Nur, “Dampak Penggunaan Meta Artificial Intelligence Pada WhatsApp Terhadap Cara Berpikir Mahasiswa Saat Diskusi di Kelas,” J. Kependidikan, vol. 13, no. 1, pp. 45–58, 2025, doi: 10.24090/jk.v13i1.13189.

[15] N. N. N. Puspawati and M. Y. Febrianta, “Analisis Pengaruh Keterjangkauan Teknologi Informasi Dalam Live Shopping Untuk Menciptakan Purchase Intention Pada Live Shopping Tiktok,” J. Ilm. Manajemen, Ekon. Akunt., vol. 7, no. 2, pp. 640–665, 2023, doi: 10.31955/mea.v7i2.3032.