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The Effect of WhatsApp-Integrated Meta AI Chatbot on Vocational Students' Critical Thinking Skills in the Automotive Engineering Basic Subjects

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ABSTRACT

The integration of artificial intelligence (AI) into vocational education offers new opportunities to enhance students' higher-order thinking skills, particularly critical thinking. However, empirical evidence on the effectiveness of AI chatbots in supporting critical thinking within vocational automotive learning remains limited. This study investigates the effect of a WhatsApp-integrated Meta AI chatbot on vocational students' critical thinking skills in the Automotive Engineering Basic Subjects. This research employed a quantitative quasi-experimental design with a non-equivalent control group. The participants were 40 tenth-grade vocational high school students divided into an experimental group (n = 20) and a control group (n = 20). The experimental group used a Meta AI chatbot integrated with WhatsApp as a learning companion during four instructional sessions, while the control group received conventional instruction. Data were collected using a validated critical thinking test measuring analysis, evaluation, and inference skills. Statistical analysis included descriptive statistics, assumption tests, independent samples t-tests, N-gain analysis, and simple linear regression. The results indicate a significant difference in critical thinking scores between the experimental and control groups ($t(38) = 2.466$, $p = 0.018$). The effect size was categorized as medium-to-large (Cohen's $d = 0.78$). The experimental group also showed a moderate improvement (N-gain = 0.45). Regression analysis revealed that the use of the Meta AI chatbot explained 18% of the variance in students' critical thinking performance ($R^2 = 0.18$, $p = 0.029$). These findings suggest that integrating AI chatbots through widely used communication platforms such as WhatsApp can support the development of critical thinking in vocational education, particularly in technical problem-solving contexts.

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1. INTRODUCTION

Vocational education plays a strategic role in preparing competent and adaptive graduates for the dynamics of the industrial world. Schools' Intermediate Vocational (SMK) not only aim to equip students with technical skills but also to develop high cognitive skills, especially the ability to think critically. In a vocational context, thinking critically is an important foundation for students to analyze problems, evaluate information, and make the right decisions in real-world situations (Kurniawan & Suryadi, 2023). However, the practice learning in many vocational schools is still mastery-oriented, with procedures and memorization material, so opportunities for students to engage in activity analysis, evaluation, and problem-solving are relatively limited.

Development intelligence: Artificial Intelligence (AI) presents an opportunity for new support, more learning, interaction, and adaptivity. One of the most common implementations of AI in education is a conversation-based chatbot that enables two-way interaction between students and the system's learning. Through dialogue, questions lighter and bait come back directly. Chatbots have the potential to serve as scaffolding cognitive tools that help students gradually build conceptual understanding. A number of studies show that AI chatbots can increase involvement in learning and supporting activity levels if designed in harmony with objective pedagogical principles (Fidan & Gencel, 2022).

Although the existing findings are still largely context-driven, education is generally context-driven. In vocational education, especially in the field of technically demanding automotive reasoning, diagnostics, and retrieval-based decision-making, evidence on the effectiveness of AI chatbots remains very limited. Research has not yet been explained in a way specific to how interaction with a dialogic chatbot facilitates the analysis and evaluation of authentic technical problems. Thus, there is a gap in detailed research between potential AI chatbot theory and its application to the development of vocational automotive competence among professionals.

One relevant AI chatbot form in the context of a school is an integrated Meta AI Chatbot with WhatsApp. Using WhatsApp as a learning platform offers the benefit of easy accessibility and familiarity, as the application is widely used by students in everyday life. Chatbot integration into the existing platform known allows interaction. A study is ongoing in a flexible manner without the need for training in complex technical aspects (Yusuf & Widodo, 2023). However, the platform is easy to use and accessible, which raises critical questions: does the AI chatbot work as a supportive cognitive tool that deepens the thinking process, or is it precisely risky for lower-involvement cognitive students? If used only as a means to search for answers quickly.

Debate in literature on education and technology. On the one hand, AI is seen as a tool that supports learning, provides scaffolding, offers adaptive support, delivers personalized feedback, and fosters difficult reflection that is realized individually by the teacher (Luckin et al., 2022). On the other hand, there are concerns that overreliance on AI can reduce students' efforts to think independently, especially if interaction is limited to providing instant solutions without any reasoning process. Therefore, it is necessary to conduct empirical studies that systematically test the role of AI as a support, not a substitute, in developing students' critical thinking skills in vocational settings.

In a way theoretical, research-based, this work is grounded in the constructivist and cognitive scaffolding framework, which emphasizes that knowledge is built actively through interaction, questions, and reflection. In this context, the chatbot dialogue is positioned as a trigger activity at the cognitive level, as explained in the ICAP (Interactive–Constructive–Active–Passive) framework, where interaction and the construction of knowledge are expected to push for deeper understanding. Open questions, clarification of concepts, and baited dialogue-based chatbot responses are mapped as potential mechanisms to stimulate analysis and evaluation of technical automotive problems (Crompton et al., 2022).

Based on the background, the aim of this research is to test the influence of integrating Meta AI Chatbot with WhatsApp on the critical thinking ability of vocational school students in the Basic Automotive Engineering lesson. The proposed research question is: Does using Meta AI Chatbot as a

companion for learning produce greater critical thinking ability than conventional learning, after controlling for initial ability?

In line with this question, the study's hypothesis is formulated as follows:

H1: Students who study with Meta AI Chatbot assistance show greater critical thinking ability, in a statistically significant way, than students who study with conventional methods, after controlling for pre-test scores.

The expected results can contribute empirically to the study of AI utilization in vocational education, in particular in the automotive learning context. In general, the findings can serve as a basis for vocational educators in designing learning strategies that use AI chatbots effectively and pedagogically, with a focus on dialogue- and problem-solving-based learning.

2. METHOD

2.1 Research Design and Context

This study used a quantitative approach with a quasi-experimental design of the non-equivalent control group type. The study was conducted on the subject of Automotive Engineering Fundamentals at one of the Vocational High Schools (SMK) in Indonesia in the even semester of the current academic year. The quasi-experimental design was chosen because the researcher could not randomly assign individuals to treatment groups due to school policies and established class structures. This research obtained official permission from the school. All participants were provided with an explanation of the research objectives, procedures, and participant rights, and they gave informed consent. Student data were anonymized to maintain privacy and confidentiality. The use of the Meta AI Chatbot was conducted in accordance with ethical guidelines for the use of AI in education, with limitations on the chatbot's function as a learning support and a prohibition on its use for copying answers directly or outside the context of learning tasks. Interactions via WhatsApp were used solely for academic purposes and under teacher supervision.

2.2 Participants and Sampling Techniques

The study participants were 40 10th-grade vocational high school students, divided into two intact classes. One class was designated as the experimental group (n = 20), and the other as the control group (n = 20). Group assignment was based on matching initial abilities using critical thinking pretest scores to minimize initial differences between groups. Individual randomization was not performed, so this study is classified as a quasi-experimental study.

2.3 Learning Treatment

The treatment was administered over four learning sessions (4 x 90 minutes). The experimental group used the Meta AI Chatbot integrated with WhatsApp as a learning companion, while the control group followed conventional learning based on lectures, guided discussions, and written practice questions.

In the experimental group, the chatbot was used to:

1. Providing automotive case-based trigger questions,
2. Facilitate clarification of concepts through question and answer dialogue,
3. Provide initial feedback on student answers, and
4. Encourage reflection through follow *-up prompts.*

Examples of assignments include analyzing simple automotive system failures, evaluating maintenance procedures, and determining solutions based on case scenarios. The teacher serves as a facilitator, guiding the discussion, monitoring student interactions with the chatbot, and ensuring that the chatbot's use promotes analysis and evaluation rather than merely seeking instant answers. The chatbot's rules are explicitly explained at the beginning of the lesson.

2.4 Research Instruments

The primary research instrument is a critical thinking ability test in the form of descriptive and multiple-choice questions, developed based on high-level critical thinking indicators, including: (1) analysis, (2) evaluation, and (3) inference. The instrument consists of 20 questions tailored to the competencies of Automotive Engineering Basics. Examples of items include analyzing the causes of component damage and evaluating alternative technical solutions. Descriptive answers were assessed using an analytical rubric with a score range of 0–5 for each indicator. Content validity was determined through expert judgment by two vocational education lecturers and one experienced automotive teacher, with the content validity index falling in the good category. Reliability was tested using Cronbach's Alpha and showed an α value > 0.70, indicating adequate reliability.

2.5 Data Collection and Data Analysis Techniques

Data collection included pretests and posttests of critical thinking skills in both groups. The pretest was administered before the treatment to measure students' initial abilities, and the posttest was administered after all learning sessions were completed. No data were missing, and all student responses were analyzed. Data analysis included descriptive and inferential statistics. Descriptive statistics were used to report the mean, standard deviation, and level of achievement in students' critical thinking skills. Before inferential analysis, normality and homogeneity assumptions were tested. Normality was assessed using the Shapiro–Wilk test because the sample size was less than 50, and homogeneity of variance was tested using Levene's Test. To test the effect of the treatment while controlling for students' initial abilities, the primary analysis used Analysis of Covariance (ANCOVA), with posttest scores as the dependent variable, learning group as the independent variable, and pretest scores as the covariate. As a supporting analysis, an independent samples t-test was conducted on the gain scores, and an N-gain calculation was performed to illustrate improvement in students' critical thinking skills. Simple linear regression analysis with ANOVA was also used to estimate the contribution of chatbot use to the variance in critical thinking scores. All analyses were conducted using IBM SPSS version 26 software with a significance level (α) set at 0.05. Outliers were checked using boxplots, and no extreme values were found to affect the analysis results.

2.6 Methodological Limitations

The relatively small sample size limits the generalizability of the findings. However, the use of a quasi-experimental design, control for prior ability through ANCOVA, and fulfillment of statistical assumptions provide adequate internal validity. This research is positioned as an initial contextual study that can serve as a foundation for further research with a broader sample size.

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 General Overview of Research Implementation

This study was conducted with students in Grade 10 of the Vocational Program in Automotive at SMK Negeri 1 Tambang. The study consisted of two groups: an experimental group and a control group, each with 20 participants. The control group used conventional learning without AI-based chatbots, while the experimental group used intervention learning with Meta AI Chatbot in the WhatsApp application.

The experimental classroom design was based on dialogue, exploration of concepts, and problem-solving in automotive technology. Students were encouraged to interact actively with Meta AI through analytical questions, case discussions, and concept clarification, while the teacher served as a facilitator, guiding critical thinking and validating the resulting answers.

3.1.2 Descriptive Data of Critical Thinking Test Scores

Descriptive analysis was conducted to compare students' critical thinking test scores before and after treatment in the experimental and control groups.

Table 1. Descriptive Statistics of Pretest and Posttest Scores

Class	Average Pretest Results	Average Posttest Results	Information
Test	62.25	77.75	Happen Improvement Higher
Control	61.25	73.5	Happen Improvement

Descriptive analysis shows improvement in the critical-thinking score for the second group. Although this is the case, the class experiment shows further improvement, exceeding that of the control group. Post-test performance in the class experiment exceeds that of the control class, indicating a positive impact from MetaAI Chatbot compared with the results of the student study.

3.1.3 Assumption Test Statistics

Before testing the hypothesis, assumption testing is carried out for normality and homogeneity. Data normality is tested using the Shapiro–Wilk test because the sample size is less than 50. The test results show that the overall pretest and posttest scores in both groups are normally distributed ($p > 0.05$).

Table 2. Normality Test Results

		Kolmogorov- Smirnov			Shapiro-Wilk		
	Class	**Statistics**	**df**	**Signature**	**Statistics**	**df**	**Signature**
score test think critical	Pre -test Experimental Class	0.204	20	0.029	0.957	20	0.480
	Pre-test Control Class	0.154	20	0.200 *	0.954	20	0.435
	Post -Test Experimental Class	0.200	20	0.035	0.910	20	0.063
	Control Class Post -Test	0.182	20	0.080	0.924	20	0.117

The results of the Shapiro-Wilk test show that the pretest and posttest data from the group experiments and the control group have p-values exceeding 0.05, indicating a normal distribution. The homogeneity of variance test, using Levene's Test, shows a significance mark of 0.673 (> 0.05), indicating that the variance between groups is homogeneous. Thus, the data meet the requirements for parametric statistical analysis.

Table 3. Results of Homogeneity Test

		Statistics Levene	df1	df2	Signature
score test think critical	Means	.181	1	38	0.673
	Median	0.058	1	38	0.811
	Median and with adjusted df	0.058	1	36,556	0.811
	Based on truncated average	.198	1	38	0.659

Test results show a mark of significance of 0.673 (>0.05), indicating that the variance in the second group is homogeneous. With fulfillment of the conditions of normality and homogeneity, further data

analysis is carried out using parametric tests. With fulfillment of the hope of normality and homogeneity, the research data meet the conditions for analysis using parametric statistical tests.

3.1.4 Hypothesis Testing (t-Test)

Before the mean difference test was performed, the data met the assumption of homogeneity of variance. Levene's test showed a p-value of 0.673 (> 0.05), indicating that the second group's variance is homogeneous. Analysis will continue with an independent t-test under the assumption of equal variance.

Table 4. Sample t-Test Results Independent

		Levene's Test For Similarities Variance		t-test for Average Similarity						
		F	Signature .	T	df	Sig. (2 tails)	Average Difference	Difference Error Standard	95% Confidence Interval of Difference More low	On
score test think critical	Same variance assumed	.181	0.673	2,466	38	0.018	4,250	1,723	0.761	7,739
	Same variance No assumed			2,466	37,804	0.018	4,250	1,723	0.760	7,740

An independent t-test yielded t = 2.466, df = 38, and Sig. (2-tailed) = 0.018 (<0.05). The mean difference was 4,250. This result shows a significant difference in critical thinking ability between the experimental group and the control group. A significance value (p-value) below 0.05 indicates acceptance of the alternative hypothesis (H_1).

3.1.5 Size Effect

To complement the significance test results, the effect size was calculated using Cohen's d. The calculation yielded d = 0.78, with a 95% confidence interval [0.14; 1.40], which falls within the medium-to-large category, indicating that the use of Meta AI Chatbot has a fairly strong practical impact on improving students' critical thinking skills.

3.1.6 Interpretation of N Gain

Normalized gain (N-gain) analysis was used to describe the increase in students' critical thinking skills in both groups.

Table 5. Test Results Gain

		Class		Statistics	Error Standard
Profit_Score_N Percent	Experimental Class	Means		37.7749	4.18136
		95% Confidence Interval for the Mean	Lower Limit	29.0232	
			Upper Limit	46.5266	
		Average Cut 5%		37.6511	
		Median		40,000	
		Difference		349,676	
		Deviation Standard		18.69963	

		Minimum	0.00	
		Maximum	77.78	
		Range	77.78	
		Range Interquartile	19.64	
		Inclination	-.250	0.512
		Kurtosis	0.851	0.992
	Control Class	Means	29.5860	3.47661
		95% Confidence Interval for the Mean	Lower Limit 22,3094	
			Upper Limit 36.8627	
		Average Cut 5%	30.4042	
		Median	34.8485	
		Difference	241,737	
		Deviation Standard	15.54788	
		Minimum	0.00	
		Maximum	44.44	
		Range	44.44	
		Range Interquartile	25.18	
		Inclination	-1,029	0.512
		Kurtosis	-.253	0.992

Table 6. Comparison N Gain of Experimental Class vs. Control Class

Aspect	Test	Control	Meaning
Average N-Gain	37.77%	29.59%	Experiment level carry on
Maximum	77.78	44.44	Impact from experiment the more strong .
Variation	More big	More small	Response student more diverse .
Category	Moment This	Low – Medium	A superior experiment

Analysis shows a difference in improvement ability in critical thinking between the second group. Based on the SPSS output, the average N-Gain value in the class experiment is 37.77% with a standard deviation of 18.70, while in the class control, the average N-Gain value was 29.59% with a standard deviation of 15.55. The N-Gain value indicates that improvement in critical thinking among students in the class experiment is in the moderate category, whereas improvement in the class control is in the low-medium category.

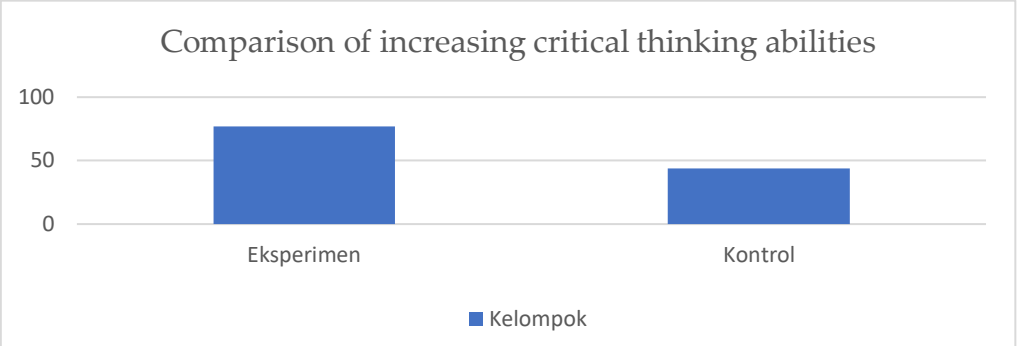

Figure 1. Comparison Improvement ability think critical

In a descriptive way, this confirms that learning with the integrated Meta AI Chatbot on WhatsApp has a greater impact on critical thinking ability than conventional learning. Thus, it can be concluded that there is a substantial difference in critical thinking ability between students who study using the integrated Meta AI Chatbot on WhatsApp and those who use conventional learning methods. The findings also prove that the use of Meta AI Chatbot has a real impact on increasing students' critical thinking ability. In addition to showing statistically significant results, the study also indicates a meaningful pedagogical impact. This is shown by a difference in critical thinking skills between the second class and the higher N-Gain score in the experimental class. The findings show that using Meta AI Chatbot not only produces a statistically significant difference but also a significant increase in the quality of students' critical thinking processes in vocational learning.

3.1.7 Analysis of the Effect of Using Meta AI Chatbot on Critical Thinking Skills (Regression Analysis and ANOVA Test)

To evaluate the impact of the use of Meta AI Chatbot on students' critical thinking ability, a simple regression analysis was conducted, followed by an ANOVA test.

Table 7. Analysis Regression

	Model	Amount Square	df	Mean Square	F	Signature .
1	Regression	117,522	1	117,522	5,646	0.029 [b]
	Remainder	374,678	18	20,815		
	Total	492,200	19			

Analysis results show an F value of 5.646 with a confidence level of 0.029 (<0.05). This Finding shows that the integrated use of Meta AI Chatbot with WhatsApp has a significant influence on critical-thinking students. Therefore, the hypothesis that states that the use of AI chatbots affects the ability to think critically can be accepted.

3.2 Discussion

Research results show that integrating Meta AI Chatbot with WhatsApp is influential in improving critical thinking ability among vocational school students in Basic Automotive Engineering lessons. Students who take this course with chatbot assistance achieve better results compared to those who study using conventional methods. This improvement in critical thinking occurs because chatbots serve as learning support that encourages active student interaction. Through trigger questions, concept clarification, and feedback, students are pushed to analyze problems, evaluate answers, and draw logical conclusions. This process aligns with constructivist theory, which emphasizes that knowledge is built actively through learning experiences and problem solving, especially in vocational learning

that is contextual and applicable. Theoretically, these findings align with constructivist methods, which emphasize the active role of students in building knowledge through involvement and reflection. In vocational education, Meta AI Chatbot serves as helpful digital scaffolding that supports students in analyzing automotive problems, evaluating alternative solutions, and drawing logical conclusions. Therefore, integrating AI-based chatbots into vocational learning can be an innovative strategy to improve learning quality and strengthen critical thinking among students.

Findings from this study are in line with those of study Baskara (2023) and Deng and Yu (2023), which stated that AI-based chatbots can increase students' learning engagement and critical thinking ability if used in accordance with learning objectives. The difference is that this study was conducted in a vocational education context with a demanding automotive technical problem-solving solution. Therefore, a chatbot not only functions as a source of information but also as a tool to help students think, understand concepts, and analyze similar real-world problem conditions.

Equality ability among beginning students in group experiments and controls, based on pretest results, strengthens the validity of the study. Improvement in posttest scores is higher in the group experiments, and regression analysis results show that the use of Meta AI Chatbot contributes to improving students' critical thinking ability. However, some limitations need to be noted, such as the use of a group that is not fully random, a relatively short treatment duration, and the possibility of novelty effects and interaction between students via WhatsApp.

The use of AI chatbots in learning is also necessary, accompanied by teacher supervision, to avoid dependence, overuse, and the use of answers in a direct, thoughtless way. In this study, the teacher plays a role as a facilitator who ensures that chatbots are used as a tool to help with discussion and reflection, not as a substitute for the learning process for students. This is in line with the opinion of Fidan and Gencel (2022), who emphasize the importance of the educator's role in the direct use of AI to support the development of critical thinking abilities.

In a practical study of results, this shows that the integrated Meta AI Chatbot on WhatsApp can be used as a support tool for learning in vocational schools, especially in subjects that require analytical lessons and technical problem-solving. Teachers are advised to compile a guide for using chatbots, provide high-level questions, and adapt evaluations to the expected critical thinking competencies.

Study the research's own limitations on the number of samples and the coverage locations. Therefore, the research also recommended involving a larger number of participants, a longer duration of learning, and a mixed-methods approach to obtain a clearer, more comprehensive picture of the utilization of AI chatbots in vocational learning.

4. CONCLUSION

The study concludes that integrating Meta AI Chatbot with WhatsApp enhances vocational high school students' critical thinking skills in Automotive Engineering Fundamentals. Students who learned using AI chatbot support showed greater improvement in critical thinking ability than students who learned through conventional instruction. Practically, the findings of this study have crucial implications for vocational high school teachers, suggesting that they integrate AI as an innovative learning medium that supports 21st-century skills, particularly critical thinking. However, the effectiveness of AI chatbots depends heavily on pedagogical design and teacher support, so that the technology is used as a thinking aid rather than simply as a provider of instant answers. Therefore, the planned and targeted integration of Meta AI Chatbots has the potential to become a relevant and sustainable learning strategy to enhance the quality of vocational learning in the digital era.

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