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The Effect of Gemini AI Accuracy Perception and Digital Literacy on Students' Economic Learning Outcomes

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Abstract

The use of artificial intelligence (AI) in education continues to increase along with the development of digital technology and ease of access to information. Gemini AI can help students understand the material and complete tasks more effectively, but it also has the potential to generate dependency if not balanced with adequate evaluation skills. This study aims to analyze the effect of Gemini AI Accuracy Perception and digital literacy on economic learning outcomes of students in SMA Negeri 4 Sidoarjo. This study uses a quantitative approach with SEM-PLS analysis technique using WarpPLS software. The sample consisted of 158 students selected through simple random sampling. Data collection is done through questionnaires. The results showed that the perception of accuracy Gemini AI and digital literacy have a positive and significant effect on students economic learning outcomes, with coefficient values of 0.301 and 0.347, respectively. The R2 value of 0.311 indicates that there are 68.9% of other factors that influence learning outcomes, such as teaching methods, motivation, and learning environment. Thus, the 31.1% contribution of both variables remained meaningful as predictors of learning outcomes, particularly in the context of behavioral and educational research that emphasizes the identification of key predictors.

Keywords: Gemini AI, Perceived Accuracy, Digital Literacy, Economic Learning Outcomes, SEM-PLS

INTRODUCTION

The rapid development of artificial intelligence (AI) has significantly transformed various sectors, including education. According to Russell et al. (2020) AI refers to systems capable of performing tasks that normally require human intelligence, such as learning, problem solving, and decision making. In education, generative AI technologies such as Google Gemini AI are increasingly being used by students because they can provide instant explanations, summarize material, and help complete tasks (Dwivedi et al., 2023). In economic learning, Gemini AI is often used to explain economic concepts, analyze cases, and quickly find supporting information. Although AI offers efficiency and accessibility in learning, its extensive use also raises concerns about plagiarism, over-reliance on AI-generated answers, and decreased critical thinking skills among students (Farrokhnia et al., 2023).

The risk of dependence on AI numerical answers is becoming the most crucial aspect in economic learning. In contrast to text-based subjects, Economics at the high school level demands an understanding of accurate calculations related to price elasticity, equilibrium prices, to national income calculations, where a single number error can change the entire conclusion. Artificial intelligence such as Gemini AI is prone to numerical hallucinations, that is, the tendency to produce erroneous

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numbers but presented with full confidence (Shirota et al., 2025). This happens because the AI only calculates based on estimates, not accurate calculations. It is this weakness that makes its use in economic calculations necessary for critical thinking.

In Cognitive Load Theory Sweller (1988) this theory explains that deep understanding is only formed through gradual practice. When students use AI to bypass the calculation stage, students lose the opportunity to build that understanding. As a result, even though students get answers from AI, students don't quite understand the process behind it. In the long run, this can hinder student's ability to deal with new economic problems that they have never encountered before. learning in the context of AI was also conveyed by Qadir & Mumtaz (2026) in his study discussing that learning from AI identifies students often experience double confidence calibration failures, namely automation bias conditions that are too confident or actually too skeptical. Students may accept the wrong number from Gemini as the truth, then use it in answering the question without realizing the error. Research by Song et al. (2025) also found that students who received false AI predictions but were presented convincingly were actually more likely to think the AI was accurate and reliable, creating a gulf between perception and actual accuracy.

The use of AI in economic calculations also risks causing cognitive offloading, which is the habit of shifting the burden of thinking to external tools. Similar research by Gerlich (2025) that this habit is highly correlated with decreased critical thinking ability. In economics, this is especially dangerous because understanding concepts is not only a matter of memorizing formulas, but also the ability to analyze the relationship between variables, for example, how price changes affect demand. When students continue to rely on AI, they lose the opportunity to develop quantitative reasoning that is only formed through practice and reflection (Atutxa et al., 2025).

One of the important factors influencing the use of AI in learning is student perception of the accuracy of the information generated by Gemini AI. Perception, according to Thórisson et al. (2021) is the subjective process of interpreting and giving meaning to information received from the environment. In the context of AI, perceived accuracy refers to a user's belief regarding the correctness, reliability, and trustworthiness of AI-generated information (Schepman & Rodway, 2020). The technology acceptance Model proposed by Davis (1989) explains that the perception of usability and ease of use greatly affect the acceptance of technology by users. Therefore, students who find Gemini'S AI accurate and useful are more likely to rely on it during the learning process. However, generative AI has limitations such as hallucinations and algorithmic bias (Bender & Mcmillan-major, 2021). In an educational context, this can lead to misinformation that negatively impacts student understanding if used without critical evaluation (Farrokhnia et al., 2023).

In addition to the perception of accuracy towards AI, digital literacy also plays an important role in determining how students use AI responsibly. According to Gilster (1998), digital literacy is not only related to technical skills, but also the ability to understand and evaluate digital information.

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Furthermore, Listia (2020) defines digital literacy as the ability to find, evaluate, use, and share information effectively and ethically through digital technology. In the context of AI, digital literacy includes the ability to verify information, recognize AI limitations, and use AI as a learning support tool, not as a substitute for thought processes (Nygren & Guath, 2022). Students with high digital literacy tend to re-examine AI-generated information and critically evaluate its credibility, whereas students with low digital literacy are more likely to passively accept information and rely too heavily on AI output (Tsz et al., 2021).

Learning outcomes are also an important aspect in evaluating the effectiveness of using AI in education. According to Bandura (1977) through Social Cognitive Theory, learning outcomes are influenced by the interaction between personal, behavioral, and environmental factors. In formal education, learning outcomes reflect student academic achievement obtained through learning activities and assessments (Ding et al., 2024). In learning, the use of AI Gemini can support students in understanding theory, analyzing economic problems, and improving learning efficiency ((Imran & Almusharraf, 2024). However, excessive reliance on AI without critical thinking and verification can reduce students ' conceptual understanding, originality, and self-learning ability (Farrokhnia et al., 2023; Perkins et al., 2020).

Several previous studies have shown that AI technology can positively influence learning engagement and academic achievement. Imran & Almusharraf (2024) found that generative AI can function as a personal learning assistant capable of supporting students understanding of learning materials Luan et al. (2025) also revealed that Gemini AI increases student engagement and participation in the learning process. In addition, Wu & Zhang (2025) highlight the close relationship between digital literacy and the use of AI technology in education, whereas firjatullah et al. (2025) found that the use of AI applications significantly affects learning outcomes. Nonetheless, research on AI literacy itself is still dominated by the context of higher education and text-based tasks while studies on the use of AI in solving quantitative problems such as economic mathematics are still limited to college students whereas, high school students are active users of generative AI who are prone to cognitive offloading.

The novelty of this study lies in the integration of perceived accuracy and digital literacy variables Gemini AI in assessing the economic learning outcomes of students of SMA Negeri 4 Sidoarjo. The study specifically focuses on how students understand the accuracy of information generated by Gemini AI and how digital literacy supports the responsible use of AI in learning. This research is important for two reasons. First, students tend to experience excessive dependence on AI without performing critical verification of the resulting answers (Farrokhnia et al., 2023). Second, research shows that student digital literacy abilities, especially in evaluating sources and evidence of digital information, are still relatively low (Nygren & Guath, 2022). Therefore, this study is expected to contribute theoretically to the development of technology-based educational literature and practically to the development of Responsible AI-assisted learning strategies in secondary education. This study aims to analyze and

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understand the relationship between the perception of accuracy of AI Gemini and digital literacy on economic learning outcomes of students at SMAN 4 Sidoarjo.

RESEARCH METHODS

This study uses a quantitative approach to measure the effect of perception accuracy on Gemini AI (X1) and digital literacy (X2) on students economic learning outcomes (Y). The criteria of research subjects were students of Class XI and XII who took the subjects of Economics specialization.

Figure 1. Conceptual Framework

Samples were taken by simple random sampling technique. The sample size determination follows the SEM-PLS criteria. Based on the 10 times rule Barclay et al. (1995) with the highest number of indicators as many as 5, a minimum of 50 respondents are required. Furthermore, using the inverse square root method Kock & Hadaya (2018) to achieve 80% power at α =0.05 with an estimated smallest path coefficient of 0.20, a minimum sample requirement of 155 respondents was obtained. The sample collected by 158 respondents has exceeded both thresholds and was declared adequate.

The measurement Model uses reflexive indicators for all latent variables. Variable accuracy of perception of Gemini AI (X1) adapted from Afroogh et al. (2024), digital literacy (X2) of Laar et al. (2020), and the economic learning outcomes (Y) of Zhai et al. (2024). Details of the indicators are presented in Table 1:

Table 1. Indicator Measurement Model

Variable	Operational Definition	Code	Indicator	Measurement Scale
Gemini AI accuracy perception (X_1)	The user's subjective belief in the correctness, accuracy and reliability of the information generated by	GAAP 1	1. Confidence in the veracity of information	Likert Scale 1-5 : 1= Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree
		GAAP 2	2. Perception of credibility and expertise.	

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	Gemini AI (Afroogh et al., 2024).	GAAP 3	3. Trust in the context of academic tasks	5 = Strongly Agree
Digital Literacy (X_2)	Ability to find evaluate, utilize, disseminate, and create information effectively and responsibly using digital technology (Laar et al., 2020).	DL 1	1. Ability to search or access information.	Likert Scale 1-5: 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
		DL 2	2. Ability to evaluate and verify information.	
		DL 3	3. Ability to manage and coordinate information.	
		DL 4	4. Ability to evaluate and collaborate.	
Economic Learning Outcomes (Y)	Achievement of cognitive abilities obtained by students after the learning process, which is measured through understanding, problem solving, and academic achievement (Zhai et al., 2024).	SELO 1	1. Conceptual understanding	Likert Scale 1-5: 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
		SELO 2	2. Problem solving skills.	
		SELO 3	3. Academic achievements	

Data were collected through questionnaires and analyzed by SEM-PLS using WarpPLS. Before further analysis, validity (outer loading >0.70; AVE >0.50) and reliability (composite reliability and Cronbach's alpha >0.70) declared feasible, structural model evaluation continued with fit assessment, R-square test, and hypothesis test based on path coefficient and p-value (Hair et al., 2021).

RESULTS AND DISCUSSION

Result

Fit Model evaluation is used to evaluate the level of conformity between the research model with empirical data obtained.

Table 2. Fit Model and Quality Indices

Num.	Model Fit And Quality Indices	Fit Criteria	Analysis Results	Description
1.	Average path coefficient (APC)	P<0,05	0.324 P<0.001	Qualified Fit model
2.	Average R-squared (ARS)	P<0,05	0.311 P<0.001	Qualified Fit model
3.	Average adjusted R-squared (AARS)	P<0,05	0.303 P<0.001	Qualified Fit model

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4.	Average block VIF (AVIF)	acceptable if <= 5, ideally <= 3.3	1.301	Ideal
5.	Average full collinearity VIF (AFVIF)	acceptable if <= 5, ideally <= 3.3	1.357	Ideal
6.	Tenenhaus GoF (GoF)	small >= 0.1, medium >= 0.25, large >= 0.36	0.450	Large
7.	Sympson's paradox ratio (SPR)	cceptable if >= 0.7, ideally = 1	1.000	Ideal
8.	R-squared contribution ratio (RSCR)	acceptable if >= 0.9, ideally = 1	1.000	Ideal
9.	Statistical suppression ratio (SSR)	acceptable if >= 0.7	1.000	Accepted
10.	Nonlinear bivariate causality direction ratio (NLBCDR)	acceptable if >= 0.7	1.000	Accepted

From Table 2, the test results showed that the average Path Coefficient (APC) of 0.324, Average R-Squared (ARS) of 0.311, and Average Adjusted R-Squared (AARS) of 0.303 were all significant at the level of $p < 0.001$. This proves that the research model has a meaningful relationship between

variables and is quite capable of explaining the phenomenon under study. Furthermore, the average Block VIF (AVIF) value of 1.301 and the Average Full Collinearity VIF (AFVIF) of 1.357 are below the ideal threshold of 3.3, which indicates that there is no multicollinearity problem in the model.

The GoF value of 0.450 is included in the large category (> 0.36), reflecting a strong level of conformity between the proposed model and empirical data. Thus, it can be concluded that the entire feasibility index of the model has met the required criteria.

The loading factor value is used to see how strong the indicator can represent the research variable. The higher the value, the better the indicator explains the measured variable. In this study, the value of the loading factor above 0.50 is valid and feasible to use.

Table 3. Variable Profile

Num.	Indicator	Factor Loading	Average	Recommendation for SMAN 4 Sidoarjo
1.	GAAP 1	0.799	3,1	Enhanced
2.	GAAP 2	0.853	3,4	Enhanced
3.	GAAP 3	0.852	3,5	Enhanced
4.	DL 1	0.834	4,1	Defend
5.	DL 2	0.755	3,7	Enhanced
6.	DL 3	0.766	3,6	Enhanced
7.	DL 4	0.828	4,1	Defend
8.	SELO 1	0.811	3,6	Enhanced
9.	SELO 2	0.838	3,7	Enhanced
10.	SELO 3	0.708	3,2	Enhanced

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Based on the table 3 of variable profile test results, all indicators of Gemini AI accuracy perception variables (X1), digital literacy (X2), and student Economic learning outcomes (Y) have a loading factor value above 0.50, with a range between 0.708 to 0.853. This shows that each indicator is valid and worthy of use because it is able to represent the variables it measures well. The average value of all indicators is in the range of 3.1 to 4.1, which indicates that the respondent's perception of each indicator is quite high. Thus, all indicators on these three variables are recommended to be improved in the future in order to strengthen the measurement of research variables in SMA Negeri 4 Sidoarjo.

Hypothesis testing is used to see the effect between variables. In addition, hypothesis testing also helps show the direction of the relationship and the significance of the influence between the variables studies.

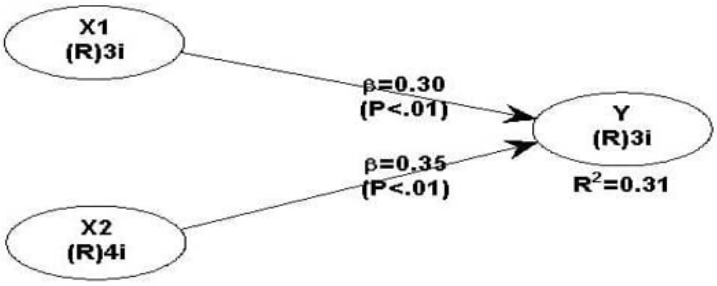

Figure 2. Hyphotesis

Overall, figure 2 shows that Gemini AI's perception of accuracy and Digital literacy are shown to have a positive and significant influence on economic learning outcomes. Both variables contribute together at 31%, with Digital literacy as a slightly more dominant variable of influence.

Hypothesis testing is done by comparing the value of p-value to the significance level of 0.05. The hypothesis is accepted if the p-value < 0.05 (significant) and rejected if the p-value > 0.05 (insignificant). The magnitude of the influence between variables is measured through the value of the path coefficient (β), where the greater the absolute value of the β (close to 1), the stronger the influence, with the direction of the coefficient must be in accordance with the hypothesis formulated.

H1: Gemini AI accuracy perception has a positive and significant effect on students economic learning outcomes
H2: Digital literacy has a positive and significant effect on economic learning outcomes.

Table 4. Direct Effect Hypothesis Test

Num.	Relationship Between Variables		Path Coefficient	p-value	Description
1.	GAAP	SELO	0.301	p<0.001	Highly Significant
2.	DL	SELO	0,347	p<0.001	Highly Significant

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H1 = Gemini AI accuracy perception has a positive and significant effect on students economic learning outcomes

From Table 4, Test the effect of variable GAAP on variable SELO obtained results of 0.301 with a significance level of p < 0.001, so it is categorized as highly significant and hypothesis (H1) is accepted. In addition, the positive coefficient (0.301) indicates that the higher the perception of accuracy towards Gemini AI (GAAP) will be followed by an increase in student Economic learning outcomes (SELO).

H2 = Digital literacy has a positive and significant effect on economic learning outcomes.

Test the effect of variable DL on variable SELO showed results of 0.347 with a significance level of p< 0.001. So it is categorized as highly significant and the hypothesis (H2) is accepted. The positive coefficient (0.347) also indicates that the higher the student's digital literacy (DL) will be followed by an increase in the student's economic learning outcomes (SELO).

R-Square test in WarpPLS is used to determine how much the ability of the independent variable in explaining the dependent variable in the research model. The higher the value of R-Square, the greater the influence of the independent variable in explaining the dependent variable. In general, values of 0.75 include a strong Category, 0.50 a medium category, and 0.25 a weak Category.

Table 5. R-Square Test

Variable	R-Square	Categories
SELO	0.311	Mediun

From Table 5, The R-Square test is used to see the simultaneous effect of GAAP and DL on SELO. Based on the results obtained the value of R-square of 0.311. The value showed that the variable perception accuracy Gemini AI and digital literacy were able to explain 31.1% of the variation in students economic learning outcomes, while the remaining 68.9% were influenced by other factors outside the research model, so the hypothesis (H3) Gemini AI accuracy perception and digital literacy simultaneously significantly affect students economic learning outcomes.is accepted.

Discussion

Gemini AI Accuracy Perception has a positive and significant effect on students economic learning outcomes

Based on the results of research that has been presented, it shows that the perception of Gemini AI accuracy has a positive effect on the economic learning outcomes of students of SMA Negeri 4 Sidoarjo. The higher the student's confidence in the accuracy of the information provided by Gemini AI, the better the economic learning outcomes achieved. Thus, H1 is declared accepted. Theoretically, these findings are aligned with the Technology Acceptance Model (TAM) developed by Davis (1989) this Model explains that a person's acceptance of technology is determined by two main factors, namely perceived

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usefulness and perceived ease of use. In the context of this study, confidence in the usefulness of technology arises when students assess that Gemini AI is accurate in presenting information and is able to explain economic material appropriately.

This finding is in line with Shin (2021) who stated that understanding how AI works builds user trust. Kasneci et al. (2023) affirm that the potential of AI in learning depends on the guarantee of accuracy of its content. Wu & Zhang (2025) also found a positive impact of AI on learning outcomes when the information presented is reliable. Nonetheless, Dai et al. (2025) warned that over-reliance on AI could reduce students learning independence. In this study, AI's direct contribution to learning outcomes is relatively small. Indicating that other factors such as motivation, learning environment, discipline, and technological readiness of students also played an important role. Therefore, Gemini AI's perception of accuracy has an effect on economic learning outcomes, but needs to be balanced with self-control so that students do not rely too much on AI.

Digital literacy has a positive and significant effect on students economic learning outcomes

The results of the analysis that has been presented show that digital literacy has a positive effect on the economic learning outcomes of students of SMA Negeri 4 Sidoarjo. The higher the student's digital literacy level, the better the economic learning outcomes achieved. Thus, H2 is declared acceptable. Theoretically, this finding aligns with the concept proposed by Gilster (1998) that digital literacy is not only limited to the skills of using devices, but also includes the ability to think in understanding, assessing, and integrating digital information into knowledge. In the context of this study, students digital literacy is mainly formed by the ability to access and assess digital information, utilize technology to learn, and process digital learning resources independently and critically.

These findings are supported by Luan et al. (2025) who stated that digital literacy is an important factor in influencing student learning achievement, as well as Yaseen et al. (2025) which affirms that digital literacy can encourage students learning independence. Manuel et al. (2023) also showed that digital literacy is related to students critical thinking skills in understanding economic concepts. In addition to digital literacy, other factors such as learning motivation, independence, the use of AI technology, and teaching quality also affect student learning outcomes. Based on all these findings, it can be concluded that digital literacy plays an important role as a strategic competence in improving students economic learning outcomes in the modern era

Gemini AI accuracy perception and digital literacy simultaneously significantly effect students economic learning outcomes

The results of the analysis prove that Gemini AI's perception of accuracy and digital literacy simultaneously have a positive effect on students economic learning outcomes. H3 is accepted. Theoretically, this finding is in line with Bandura (1977) which explains that learning behavior is the result of interactions between personal, environmental, and behavioral cognitive factors. In this study, AI accuracy

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perception plays a role as a personal cognitive factor, while digital literacy plays a role as an environmental factor. The interaction of the two promotes the improvement of students economic learning outcomes.

These findings are supported by Luan et al. (2025) that the utilization of AI in learning, including the perception of AI accuracy, contributes significantly to improving academic achievement. Wu & Zhang (2025) and Yaseen et al. (2025) also shows that the integration of digital literacy and trust in AI can improve the quality of learning outcomes and encourage student learning independence. Manuel et al. (2023) reinforce that students with high digital competence and accustomed to interacting with AI show better critical thinking skills. Thus, it was concluded that the perception of accuracy Gemini AI and digital literacy simultaneously contributes significantly to the economic learning outcomes of students, because the interaction between confidence in the reliability of AI and the ability to make critical use of digital technology is able to create conducive learning condition.

CONCLUSION

Based on the findings and analysis obtained, it can be concluded that the perception of Gemini AI accuracy and digital literacy partially or simultaneously proved to have a positive and significant effect on students economic learning outcomes. These findings confirm that increased student confidence in the accuracy of information from AI output, along with high digital literacy skills, can support the creation of more effective economic learning processes and contribute to improved learning outcomes.

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