



The Implementation of Artificial Intelligence (AI) Technology and Students' Digital Literacy on Learning Outcomes in the Economics Learning Evaluation Course

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Abstract

The advancement of information technology requires students to possess digital literacy skills, while the implementation of Artificial Intelligence (AI) has the potential to enhance learning effectiveness. This study aims to analyze the influence of AI implementation and digital literacy on students' learning outcomes in the Learning Evaluation course. The research employed a quantitative method with a survey approach. The population comprised 90 fifth-semester students from the Economic Education Study Program, with a sample of 79 students determined using Isaac & Michael's table at a 1% significance level, through random sampling. Data were collected using instruments whose validity and reliability had been previously tested. Data analysis was conducted using partial and multiple regression. The results indicate that: (1) AI implementation has a positive effect on learning outcomes; (2) digital literacy has a positive effect on learning outcomes; and (3) AI implementation and digital literacy simultaneously have a positive effect on learning outcomes. This study contributes empirical evidence regarding the impact of AI implementation and digital literacy on students' learning outcomes, which can serve as a basis for developing learning strategies, improving the quality of higher education, and supporting the achievement of SDG 4.

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INTRODUCTION

Global digital transformation has entered the era of Society 5.0, which positions humans at the center of technological innovation based on Artificial Intelligence (AI), the Internet of Things (IoT), and big data (Rohayati & Abdillah, 2024; Rojas et al., 2021; Villiers, 2024). This development has been further accelerated since the COVID-19 pandemic, which spurred widespread and permanent digitalization in education. In this context, AI has emerged as one of the most prominent forms of transformation due to its capability to analyze learning data, provide adaptive feedback, and support decision-making based on learning analytics (Gligorea et al., 2023; Hariyanto et al., 2025; Salas-pilco et al., 2022).

This direction of transformation aligns with the global agenda of Sustainable Development Goal (SDG) 4: Quality Education, which emphasizes the improvement of educational quality, effectiveness, and accessibility through technological innovation (Nations, 2015). UNESCO (2023) asserts that AI has the potential to enhance personalized learning and the efficiency of academic assessment. However, these benefits are not automatic; they heavily depend on users' readiness in terms of digital literacy and ethical understanding of technology.

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Although the integration of AI in learning is increasingly widespread, its effectiveness on students' learning outcomes cannot be assumed directly (Treve, 2024). The implementation of AI in education without adequate digital literacy readiness may lead to superficial usage and cognitive dependency. Moreover, limited evaluative skills can increase the risk of bias in information processing (Garzón et al., 2025; Zhai et al., 2024; Zhu et al., 2025). Therefore, digital literacy is a crucial factor in determining whether technology truly enhances the quality of learning or merely serves as a technical aid.

Digital literacy encompasses not only operational skills in using technological devices but also cognitive abilities to evaluate the credibility of information, understand data context, and utilize it critically and ethically in the learning process (Tinmaz et al., 2022; Umar et al., 2025). The 2024 Telecommunication Statistics in Indonesia indicate an increase in internet access among the population from 69.21% in 2023 to 72.78% in 2024, reflecting the expanding digital penetration, including among students (Statistik, 2025). However, challenges in students' digital literacy remain significant, including difficulties in leveraging digital technology for academic purposes and limited capacity to evaluate complex content within technology-based learning contexts (Marselina et al., 2025). This situation highlights a gap between technological availability and users' competency readiness. Consequently, the primary issue is no longer merely whether AI is available in learning, but the extent to which students' digital literacy moderates or strengthens the impact of AI implementation on learning outcomes.

Previous studies indicate that digital literacy contributes to the effectiveness of technology-based learning. Ng (2012) conceptualizes digital literacy as a multidimensional construct, while Laar et al. (2017) report a relationship between digital skills and higher-order thinking skills within the context of performance in digital environments. On the other hand, research on AI in education has been predominantly focused on system development and technical aspects (Zawacki-Richter et al., 2019). In line with this, Chen et al. (2020) highlight a gap between AI technology development and its integration with learning theories. Furthermore, the AI ethics literature emphasizes that the use of AI without adequate digital literacy may lead to algorithmic bias and cognitive dependency (Holmes et al., 2022) indicating that the impact of AI on learning outcomes cannot be separated from users' competence in utilizing it.

Although the literature on AI and digital literacy has developed rapidly, most studies have examined these two variables separately. Based on the available literature, empirical research simultaneously investigating AI implementation and digital literacy within a single inferential model based on learning outcomes particularly in the context of higher education in Indonesia remains relatively limited. This gap is especially relevant in the Learning Evaluation in Economics course, which requires competencies in data analysis, instrument development, and systematic interpretation of results skills that are conceptually related to the utilization of AI and digital literacy.

Based on the theoretical foundation and the identified gaps, this study aims to analyze the effects of AI implementation and digital literacy on students' learning outcomes in the Learning Evaluation in Economics course, both partially and simultaneously. The novelty of this research lies in the development of an integrative empirical model that examines both variables within a single measurable analytical framework, as well as the use of partial correlation analysis to identify the unique contribution of each independent variable. Theoretically, this study contributes to strengthening the scholarship on AI in education based on learning outcomes within the context of economic education in Indonesia. Practically, the findings are expected to serve as a basis for developing AI-based learning strategies integrated with the enhancement of digital literacy, thereby supporting the improvement of higher education quality and the achievement of SDG 4.

METHOD

Research Method

This study employed a quantitative method with a survey approach, consistent with the characteristics of variables that can be measured numerically and analyzed statistically (Creswell & Creswell, 2018; Sugiyono, 2014). The research design was formulated to examine the effects of

Artificial Intelligence (AI) Technology Implementation (X1) and Digital Literacy (X2) on the learning outcomes of the Learning Evaluation in Economics course (Y). The research design or configuration is presented in Figure 1.

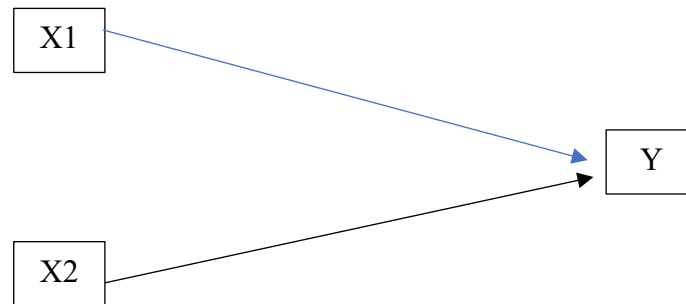


Figure 1. Research Design or Configuration

Note:

X1 = Artificial Intelligence (AI) Technology Implementation

X2 = Digital Literacy

Y = Learning Outcomes of the Learning Evaluation in Economics Course

Research Hypotheses

Based on the literature review and the objectives of this study, the following hypotheses are proposed: (1) the implementation of AI technology has a positive effect on students' learning outcomes, (2) digital literacy has a positive effect on students' learning outcomes, and (3) AI technology implementation and digital literacy simultaneously exert a positive effect on students' learning outcomes.

Population and Sample

The population of this study comprised all fifth-semester undergraduate students in the Economic Education Study Program, Faculty of Teacher Training and Education, Universitas Panca Sakti, Bekasi, totaling 90 students. Referring to Isaac & Michael (1981), with a 1% significance level, the representative sample size is 79 students. The sampling technique employed was cluster random sampling to ensure that every student group had an equal chance of being selected (Fraenkel et al., 2011).

Instrumen Penelitian

Data were collected using several instruments. The AI Technology Implementation instrument was used to measure the extent of AI utilization in the learning process. The Digital Literacy instrument assessed students' abilities to use digital technology effectively, while the Learning Outcomes Test instrument measured students' achievement in the Learning Evaluation in Economics course. Prior to administration, all instruments were tested for construct validity, empirical validity, and reliability to ensure that the data obtained were both valid and reliable (Creswell & Creswell, 2018; Sugiyono, 2014).

Research Procedure

The research procedure was carried out through several stages. The study began with research planning, which involved defining the objectives, variables, population, and sample. This was followed by the development and validation of the research instruments. Data collection was then conducted by administering the instruments to respondents in accordance with the cluster random sampling technique. Subsequently, the data were processed and analyzed using descriptive and inferential statistical methods to test the research hypotheses. Finally, the results were interpreted and discussed in relation to relevant theories and previous studies. Figure 2 illustrates the research procedure in a flow diagram.

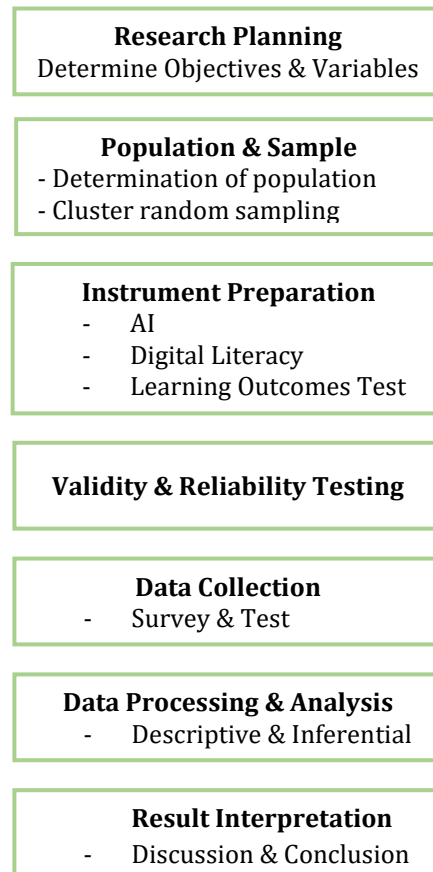


Figure 2. Research Procedure Flow Diagram

Data Analysis

Data analysis was conducted in a sequential manner, using both descriptive and inferential statistical methods. Descriptive analysis was employed to illustrate the characteristics of each research variable, including minimum and maximum values, mean, and standard deviation. This analysis aimed to provide an overview of the levels of AI technology implementation, digital literacy, and students' learning outcomes.

Assumption Testing

Before hypothesis testing was conducted, the data were examined to ensure that they met the classical regression assumptions. This included tests for normality to determine whether the data were normally distributed, linearity to confirm that the relationships between independent and dependent variables were linear, multicollinearity to detect any high correlations among independent variables, and heteroscedasticity to verify the homogeneity of residual variances. Ensuring these assumptions are met is essential for the validity and reliability of the regression analysis results.

Partial regression analysis (t-test)

Partial regression analysis (t-test) was conducted to examine the effect of each independent variable on the dependent variable. Specifically, the analysis assessed the influence of AI Technology Implementation (X1) on learning outcomes (Y) and the effect of Digital Literacy (X2) on learning outcomes (Y), with significance tested at $\alpha = 0.05$.

Multiple linear regression analysis (F-test)

Multiple linear regression analysis (F-test) was performed to investigate the simultaneous effect of X1 and X2 on Y, also using a significance level of $\alpha = 0.05$.

Coefficient of Determination (R²)

The coefficient of determination (R²) was calculated to determine the extent to which AI implementation and digital literacy contribute to explaining the variation in students' learning outcomes.

The regression equation model used in this study is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where:

Y	= Learning Outcomes
X ₁	= AI Technology Implementation
X ₂	= Digital Literacy
β ₀	= Constant
β ₁ , β ₂	= Regression Coefficients
ε	= Error Term

RESULTS AND DISCUSSION

The results of the data analysis regarding the effects of AI technology implementation and digital literacy on students' learning outcomes in the Learning Evaluation in Economics course are presented systematically through several stages. The analysis began with descriptive statistics to illustrate the characteristics of the data, followed by assumption testing to ensure that the regression assumptions were satisfied, and hypothesis testing using both partial and multiple linear regression analyses. The findings were subsequently interpreted comprehensively in relation to the theoretical framework and previous research, providing a deeper understanding of the contribution of AI implementation and digital literacy to students' learning outcomes. Descriptive statistics of the research variables are presented in Table 1, showing the distribution and central tendency of AI implementation, digital literacy, and student learning outcomes.

Table 1. Descriptive Statistics of Research Variables

Variable	N	Min	Max	Mean	Std. Deviation	Range	Median	Mode
AI Implementation (X1)		50	90	74.53	10.767	40	75	75
Digital Literacy (X2)	79	29	78	57.58	11.474	49	58	58
Learning Outcomes (Y)		52	96	80.22	10.760	44	81	81

Based on Table 1, the AI technology implementation variable (X₁) has a mean value of 74.53 with a standard deviation of 10.77, indicating that students' utilization of AI is relatively high with moderate data variation. The identical median and mode values (75) suggest a roughly symmetrical distribution. The digital literacy variable (X₂) has a mean of 57.58 and a standard deviation of 11.47, indicating that students' digital literacy is at a moderate level with considerable data variability. The identical median and mode values (58) also suggest a relatively normal distribution.

Meanwhile, the learning outcomes variable (Y) has a mean value of 80.22 with a standard deviation of 10.76, indicating that students' academic achievement is relatively high. The median and mode, both at 81, further confirm that the data distribution is approximately symmetrical and free from extreme deviations. Overall, all three variables exhibit a relatively normal distribution with moderate variability, making the data suitable for further inferential analysis.

Subsequently, assumption testing was conducted to ensure that the data met the requirements for regression analysis. The results of the normality test using the Kolmogorov-Smirnov method indicated that all research variables were normally distributed ($p > 0.05$). In addition, the homogeneity test using Levene's Test showed a significance value of 0.05, indicating that the data variances were homogeneous. Therefore, the data in this study met the criteria for further regression analysis.

Multiple Linear Regression and Coefficient Significance Test

After all the analytical assumptions were satisfied, the next stage involved testing the multiple linear regression model to examine the effects of AI technology implementation and digital literacy on students' learning outcomes. The results of the multiple linear regression analysis are presented in Table 2.

Table 2. Results of Multiple Linear Regression Analysis

Variable	Coefficient (B)	t-value	p-value	Decision
Constant	16.452			
AI Implementation (X1)	0.426	12.152	0.000	Significant
Digital Literacy (X2)	0.553	16.712	> 0.05	Not Significant

Based on Table 2, the analysis results indicate that the obtained regression model is as follows:

$$\hat{Y} = 16,452 + 0,426X_1 + 0,553X_2$$

This equation shows that AI technology implementation (X_1) and digital literacy (X_2) have a positive relationship with learning outcomes (Y). The regression coefficient of 0.426 for the AI variable indicates that for each one-unit increase in AI implementation, students' learning outcomes are expected to increase by 0.426 units, assuming all other variables remain constant. Similarly, the coefficient of 0.553 for digital literacy indicates a positive effect on learning outcomes.

The significance of the regression coefficients was tested partially using the t-test. The analysis results show that the AI technology implementation variable (X_1) had a t-value of 12.152 with a significance level of $p < 0.05$, leading to the rejection of H_0 . This indicates that AI technology implementation has a positive and significant effect on students' learning outcomes. In contrast, the digital literacy variable (X_2) showed a significance level of $p > 0.05$, leading to the acceptance of H_0 . These findings suggest that digital literacy does not have a direct significant effect on students' learning outcomes within the model used.

Significance Test of the Multiple Regression Equation

The results of the simultaneous regression test and model fit are presented in Table 3, including the multiple correlation coefficient, coefficient of determination, and F-test significance.

Table 3. Model Summary and Simultaneous Test Results

Model	R	R ²	F-value	Sig. (p-value)	Interpretation
1	0.990	0.981	311.523	0.000	Model is significant

As shown in Table 4, the model demonstrates a very strong relationship ($R = 0.990$) and a high explanatory power ($R^2 = 0.981$). The F-test result indicates that the model is statistically significant ($p < 0.05$), confirming that AI implementation and digital literacy simultaneously influence learning outcomes.

The significance of the regression model was tested using the F-test to evaluate the simultaneous effect of AI technology implementation (X_1) and digital literacy (X_2) on learning outcomes (Y). The analysis results showed an F-value of 311.523 with a significance level of $p < 0.05$, leading to the rejection of H_0 . This indicates that both independent variables jointly have a significant effect on students' learning outcomes.

Furthermore, the multiple correlation coefficient analysis showed an R-value of 0.990, indicating a very strong relationship between the independent and dependent variables. The significance test of this correlation coefficient yielded an F-change value of 1917.149 with $p < 0.05$, confirming that the relationship is statistically significant. The coefficient of determination (R^2) was 0.981, indicating that 98.1% of the variation in learning outcomes can be explained by AI technology implementation and digital literacy, while the remaining 1.9% is influenced by other factors outside the research model.

These findings indicate that the regression model employed has a very high explanatory power in accounting for the variation in students' learning outcomes. However, the exceptionally high R^2 value should be interpreted with caution, as it may reflect sample homogeneity or the influence of other variables not included in the model.

Partial Correlation Significance Test

A partial correlation analysis was conducted to examine the relationship between each independent variable and learning outcomes while controlling for the other variable. The results indicated that the partial correlation coefficient between AI technology implementation (X_1) and students' learning outcomes (Y), controlling for digital literacy (X_2), was 0.428 with a significance level of $p < 0.05$. This suggests that there is a significant relationship between AI technology implementation and learning outcomes after controlling for the effect of digital literacy.

Subsequently, the partial correlation coefficient between digital literacy (X_2) and students' learning outcomes (Y), controlling for AI technology implementation (X_1), was 0.887 with a significance level of $p < 0.05$. These results indicate that digital literacy has a significant relationship with learning outcomes, even after controlling for the effect of AI technology implementation. The results of the partial correlation analysis are presented in Table 4.

Table 4. Partial Correlation Results

Relationship	Control Variable	r (Partial)	Sig. (p-value)	Interpretation
$X_1 \rightarrow Y$	X_2	0.428	0.000	Significant (moderate)
$X_2 \rightarrow Y$	X_1	0.887	0.001	Significant (very strong)

The findings demonstrate that the implementation of AI technology has a significant positive effect on students' learning outcomes in the *Evaluation of Learning* course. This result corroborates prior studies suggesting that AI enhances knowledge acquisition, supports deeper understanding, and facilitates more adaptive learning experiences (Ansari & Qamari, 2025; Garzón et al., 2025; Memarian & Doleck, 2024). From a theoretical perspective, AI contributes to learning by enabling personalized feedback, immediate access to information, and interactive engagement, which are often absent in traditional instructional approaches. However, despite the rapid advancement of technology, its integration into classroom practice remains limited. Many learning activities are still conducted using conventional, teacher-centered methods that tend to be passive and monotonous, thereby reducing student engagement and learning effectiveness (Anjani & Anekasari, 2025). This gap indicates that the issue is not merely the availability of technology, but rather the readiness and ability of educators and institutions to integrate it meaningfully into pedagogy. In this context, AI should not be viewed solely as a technological tool, but as a pedagogical enabler that can transform learning into a more interactive, student-centered process. Therefore, higher education institutions are required to adopt and integrate AI-driven innovations systematically to enhance instructional quality. These findings are further supported by previous research indicating that digital platforms, including social media, can positively influence students' motivation and engagement in learning (Supriyadi, 2022). Accordingly, the first hypothesis is empirically supported.

Furthermore, the results reveal that the simultaneous effect of AI technology implementation and digital literacy significantly influences students' learning outcomes. This finding highlights the complementary relationship between technological tools and users' competencies. AI technology, regardless of its sophistication, cannot be optimally utilized without adequate digital literacy skills. In other words, digital literacy acts as a critical mediator that enables students to access, evaluate, and effectively use AI-based resources. This aligns with the argument that AI has evolved into a widely used communication and learning medium across various age groups, facilitating interaction, knowledge exchange, and collaborative learning (Kasneji et al., 2023). The widespread adoption of internet technologies further strengthens this relationship. In the educational context, social networking platforms such as Facebook, Blogger, Instagram, and Twitter have increasingly been integrated into learning environments (Perez et

al., 2023). These platforms are no longer limited to social interaction; they function as spaces for information dissemination, academic discussion, self-expression, and collaborative learning (Anane-donkor, 2022; Du & Ibrahim, 2025). Their accessibility and diverse features allow users from different age groups to participate in learning activities beyond the classroom. Consequently, the convergence of AI technology and digital literacy not only enhances individual learning outcomes but also promotes a more connected and participatory learning ecosystem.

Overall, these findings emphasize that improving learning outcomes requires not only the adoption of advanced technologies such as AI but also the development of students' digital competencies. The synergy between AI and digital literacy creates a more effective, engaging, and meaningful learning experience. Therefore, the proposed hypotheses are supported by empirical evidence, while also implying that future educational strategies should focus on integrating technological innovation with digital skill development to maximize learning effectiveness.

CONCLUSION

The findings of this study can be summarized as follows: first, the implementation of AI technology has a positive effect on students' learning outcomes in the Evaluation of Learning course; second, digital literacy does not have a significant positive effect on these learning outcomes; third, there is a simultaneous effect of AI technology implementation and digital literacy on students' learning outcomes; fourth, the combined influence of AI technology implementation and digital literacy on learning outcomes accounts for 80.4%; fifth, the partial correlation between AI technology implementation and students' academic achievement in Economics, controlling for digital literacy, is significant; and sixth, the partial correlation between digital literacy and learning outcomes, controlling for AI technology implementation, is also significant.

AUTHOR CONTRIBUTIONS

The authors contributed collaboratively to this study. SP was responsible for conceptualization, research design, data analysis, and manuscript drafting. ANA contributed to data collection, instrument validation, literature review, and manuscript revision. Both authors reviewed and approved the final version of the manuscript.

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