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Artificial Intelligence Literacy and Self-Regulated Learning as Predictors of Academic Writing Skills among Pre-Service Indonesian Language Teachers

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ABSTRACT

Purpose: The rapid adoption of generative artificial intelligence (AI) has transformed higher education and reshaped academic writing practices, creating a need to understand factors that support students' writing competence. Although previous studies have examined artificial intelligence literacy and self-regulated learning in technology-enhanced learning environments, empirical evidence remains limited regarding their predictive roles in academic writing among pre-service Indonesian language teachers. Therefore, this study aimed to examine the individual and joint predictive effects of Artificial Intelligence Literacy and Self-Regulated Learning on Academic Writing Skills. **Methods:** A quantitative study employing a predictive correlational design was conducted with 132 undergraduate students enrolled in Indonesian Language Education programs at several universities in Indonesia. Participants were selected through purposive sampling. Data were collected using Artificial Intelligence Literacy and Self-Regulated Learning questionnaires, while Academic Writing Skills were assessed through an academic essay-writing task using an analytic rubric. The data were analyzed using descriptive statistics and multiple linear regression with IBM SPSS Statistics. **Findings:** The results showed that Artificial Intelligence Literacy significantly predicted Academic Writing Skills (β = .448, t = 5.595, $p < 0.001$). Self-Regulated Learning also significantly predicted Academic Writing Skills (β = .271, t = 3.392, $p < 0.001$). Furthermore, Artificial Intelligence Literacy and Self-Regulated Learning jointly significantly predicted Academic Writing Skills ($F(2, 129) = 43.276$, $p < 0.001$), with the model explaining 40.2% of the variance in Academic Writing Skills. **Research Implications:** These findings suggest that teacher education programs should integrate Artificial Intelligence Literacy and Self-Regulated Learning into academic writing instruction. Such integration may help pre-service Indonesian language teachers use AI technologies critically and responsibly while maintaining self-regulated learning practices and academic writing competence.

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INTRODUCTION

The emergence of generative artificial intelligence (AI) has fundamentally transformed the educational landscape by reshaping how students access information, construct knowledge, and engage in academic tasks. The increasing availability of AI-powered applications such as ChatGPT, Gemini, Claude, and Copilot has enabled learners to generate ideas, organize content, obtain instant feedback, and support various stages of the writing process, thereby creating new opportunities for more efficient and personalized learning experiences (Utami & Winarni, 2023; Shi et al., 2025; Zhou et al., 2025). As AI technologies become more integrated into higher education, students are expected not only to utilize these tools effectively but also to critically evaluate the accuracy, credibility, and relevance of AI-generated information. Recent studies have highlighted that AI literacy is increasingly regarded as a crucial competency for university students and future educators because it facilitates informed, ethical, and responsible engagement with AI technologies in academic settings (Nabhan & Habók, 2026; Karaduman, 2025; Sevimel-Sahin &

Sahin, 2026). Nevertheless, the rapid adoption of generative AI has also raised significant concerns regarding academic integrity, overreliance on automated content generation, and the potential decline of independent critical thinking skills among students (Castillo-Cuesta et al., 2025; Octaberlina et al., 2024). In the context of teacher education, these concerns become particularly important because pre-service teachers are expected to develop the competence necessary to integrate emerging technologies into future teaching practices while maintaining high academic and ethical standards. Furthermore, educational institutions are increasingly challenged to prepare future teachers who can balance the benefits of AI-assisted learning with the development of essential cognitive and metacognitive skills required in academic environments (Ilma & Rohmah, 2025; Kohnke & Green-Eneix, 2025). Consequently, understanding the factors that contribute to students' academic performance, particularly their academic writing skills, has become an important issue in the era of generative artificial intelligence.

Academic writing skills constitute one of the most essential competencies that pre-service Indonesian language teachers must develop during their university education. As future educators, they are expected to produce academic papers, conduct research, communicate scholarly ideas effectively, and model appropriate writing practices for their future students. Academic writing requires the ability to organize ideas coherently, construct evidence-based arguments, employ appropriate academic language, and apply accurate referencing and citation practices. However, previous studies have reported that many university students continue to experience difficulties in developing coherent arguments, synthesizing information from multiple sources, and maintaining academic conventions in their writing (Umamah & Cahyono, 2020;Teng & Zhang, 2020). Similar findings indicate that weaknesses in academic writing are often associated with inadequate metacognitive regulation, limited critical engagement with information, and insufficient writing practice (Prihandoko et al., 2024). In recent years, the increasing use of AI-assisted writing tools has introduced both opportunities and challenges for writing development. While AI technologies can support idea generation and language refinement, excessive dependence on such tools may reduce students' engagement in the cognitive processes required for effective academic writing (Octaberlina et al., 2024). Therefore, identifying factors that can strengthen students' academic writing skills remains an important concern in teacher education, particularly as future Indonesian language teachers are expected to develop strong writing competence while navigating increasingly AI-mediated academic environments.

One factor that has received increasing scholarly attention is artificial intelligence literacy. AI literacy refers to an individual's ability to understand AI concepts, critically evaluate AI-generated outputs, utilize AI tools effectively, and apply ethical considerations when interacting with AI technologies (Nabhan & Habók, 2026; Sevimel-Sahin & Sahin, 2026). The concept extends beyond technical knowledge because it encompasses critical awareness, informed decision-making, and responsible technology use in academic and professional contexts. As AI becomes more prevalent in higher education, students are increasingly required to develop competencies that enable them to distinguish accurate information from misleading outputs, recognize algorithmic limitations, and use AI-generated content responsibly (Drajati et al., 2025; Sari et al., 2025). Research has shown that individuals with higher levels of AI literacy tend to demonstrate greater confidence in utilizing AI technologies and are more capable of integrating such technologies into learning activities productively (Karaduman, 2025; Wulandari & Purnamaningwulan, 2024). Conversely, insufficient AI literacy may lead to inappropriate dependence on AI-generated content, ethical violations, and reduced academic autonomy (Castillo-Cuesta et al., 2025; Octaberlina et al., 2024). Thus, AI literacy should not be understood simply as the frequency or intensity of AI use, but as a competency that enables students to evaluate, regulate, and use AI-supported information critically and responsibly. Given the growing reliance on generative AI tools in academic environments, AI literacy may therefore influence the quality of students' academic writing by shaping how effectively they engage with AI-supported information and writing processes.

Another factor that is widely recognized as contributing to academic success is self-regulated learning (SRL). SRL refers to learners' ability to actively plan, monitor, control, and evaluate their own learning processes in order to achieve specific academic goals. According to Zimmerman's self-regulation framework, effective learners engage in goal setting, strategic planning, self-monitoring, self-reflection, and time management throughout the learning process. These components are particularly important in academic writing because writing is a complex cognitive activity that requires continuous planning, drafting, revising, and evaluating written work. Previous studies have demonstrated that students with strong self-regulated learning skills are more likely to employ effective writing strategies, persist when encountering difficulties, and produce higher-quality academic texts (Teng & Zhang, 2020; Umamah & Cahyono, 2020). Furthermore, self-regulated learners tend to exhibit higher levels of academic self-efficacy, motivation, and engagement, all of which contribute positively to writing performance (Hwang, 2025; Prihandoko et al., 2024; Zenouzagh et al., 2026). Emotional regulation and metacognitive awareness have also been identified as important dimensions of SRL that enable students to manage challenges encountered during academic writing activities (Mega

et al., 2014;Zheng et al., 2024). Self-regulated learning can therefore be considered an important internal factor that may influence students' ability to develop effective academic writing skills.

The relationship between artificial intelligence literacy and academic writing has attracted growing attention in recent educational research. The integration of AI-powered technologies into writing instruction has been reported to facilitate idea generation, content development, language refinement, and personalized feedback, thereby supporting students' writing processes (Utami & Winarni, 2023; Zhou et al., 2025). Research conducted in higher education contexts has indicated that students who possess higher levels of AI literacy tend to utilize AI tools more strategically and critically during academic tasks (Shi et al., 2025; Wang et al., 2025). Similarly, Pan & Zhang (2026) found that learners with advanced AI literacy profiles demonstrated stronger writing-related self-regulation and more effective engagement with AI-assisted writing activities. Other studies have suggested that AI literacy contributes to creativity, critical thinking, and academic achievement by enabling students to use AI technologies as cognitive support tools rather than as substitutes for independent thinking (Chun et al., 2025; Yang et al., 2026). At the same time, researchers have warned that inadequate AI literacy may encourage superficial learning behaviors, excessive dependence on AI-generated outputs, and reduced originality in academic writing (Octaberlina et al., 2024; Qoyyimah & Bargallie, 2025). These contrasting perspectives suggest that the educational value of AI depends not simply on whether students use AI tools, but on whether they possess the literacy necessary to evaluate and use AI-generated information critically and responsibly. Nevertheless, empirical evidence specifically examining the predictive role of AI literacy in relation to measured academic writing performance among pre-service Indonesian language teachers remains limited.

In addition to AI literacy, numerous studies have highlighted the significant role of self-regulated learning in improving writing performance across various educational contexts. Self-regulated learning enables students to manage writing tasks systematically by establishing goals, selecting appropriate strategies, monitoring progress, and evaluating outcomes. Research by Teng & Zhang (2020) demonstrated that SRL-based writing instruction significantly improved learners' writing achievement and engagement in language learning environments. Similar findings were reported by Wang et al. (2025), who found a positive relationship between self-regulated writing strategies and academic writing performance among university students. Jin et al. (2025) further revealed that self-regulated learning plays a critical role in determining writing outcomes within AI-assisted learning environments because students who actively regulate their learning tend to benefit more from technological support. Zhang & Liang (2026) found that AI-assisted learning scaffolding becomes more effective when students possess strong self-regulatory abilities that enable them to critically engage with feedback and writing resources. Evidence from Indonesian higher education settings also indicates that students who apply self-regulated writing strategies demonstrate better organization, argumentation, and overall writing quality (Umamah & Cahyono, 2020). These findings indicate that SRL remains an important predictor of writing performance across conventional and technology-enhanced learning environments. However, much of the existing evidence has been developed in EFL, L2 writing, or broader higher education contexts, leaving comparatively limited evidence concerning pre-service Indonesian language teachers and their academic writing performance.

Despite the growing body of literature on artificial intelligence literacy, self-regulated learning, and academic writing, important gaps remain. First, although previous studies have increasingly examined AI literacy and self-regulated learning together in technology-enhanced and AI-assisted learning environments (Jin et al. 2025; Pan & Zhang, 2026; Shi et al., 2025; Wang et al., 2025), relatively limited attention has been given to their simultaneous predictive contribution to measured academic writing skills among pre-service Indonesian language teachers. Thus, the contribution of the present study does not rest on claiming that the combination of AI literacy and SRL has never been examined, but rather on extending this line of inquiry to a specific teacher-education population and academic writing context. Second, existing research on AI literacy has often emphasized technology acceptance, digital competence, perceptions, or general learning outcomes, whereas fewer studies have directly examined its predictive relationship with academic writing performance (Drajati et al., 2025;Utami & Winarni, 2023). Third, much of the existing research on AI-assisted writing and self-regulated learning has been conducted in EFL or L2 writing contexts, while evidence from Indonesian language teacher education remains comparatively scarce (Jin et al., 2025; Pan & Zhang, 2026). This population and contextual gap is particularly relevant because pre-service Indonesian language teachers require strong academic writing competence while also preparing to navigate AI-mediated educational environments. Addressing this gap may provide a more context-sensitive understanding of how technological literacy and self-regulatory competence are associated with academic writing development in teacher education. Therefore, the present study contributes empirical evidence by examining the predictive roles of AI literacy and self-regulated learning in relation to academic writing skills among pre-service Indonesian language teachers in Indonesia.

Based on the theoretical and empirical considerations discussed above, this study aimed to examine the predictive effects of artificial intelligence literacy and self-regulated learning on academic writing skills among pre-service Indonesian language teachers. Specifically, the study examined whether artificial intelligence literacy significantly predicts academic writing skills, whether self-regulated learning significantly predicts academic writing skills, and whether both variables jointly explain significant variation in students' academic writing performance. Accordingly, three hypotheses were formulated. H1: Artificial Intelligence Literacy significantly predicts Academic Writing Skills among pre-service Indonesian language teachers. H2: Self-Regulated Learning significantly predicts Academic Writing Skills among pre-service Indonesian language teachers. H3: Artificial Intelligence Literacy and Self-Regulated Learning jointly significantly predict Academic Writing Skills among pre-service Indonesian language teachers. By addressing these hypotheses, the study seeks to provide empirical evidence regarding factors associated with academic writing development in the era of generative artificial intelligence. The findings are expected to contribute to the growing literature on AI literacy, self-regulated learning, and academic writing within teacher education contexts and provide insights for curriculum developers, teacher educators, and higher education institutions seeking to develop responsible AI use alongside independent and reflective learning practices.

METHOD

Research Design

This study employed a quantitative approach using a predictive correlational research design. The design was selected because the study aimed to investigate the predictive relationships among Artificial Intelligence Literacy, Self-Regulated Learning, and Academic Writing Skills without manipulating any research variables. Predictive correlational research is particularly appropriate for examining the extent to which one or more independent variables explain variations in a dependent variable (Creswell and Creswell 2023). In the present study, Artificial Intelligence Literacy and Self-Regulated Learning served as the predictor variables, while Academic Writing Skills functioned as the outcome variable. The study was conducted in the context of Indonesian language teacher education, where academic writing competence is considered a fundamental professional skill. Furthermore, the increasing integration of generative artificial intelligence technologies in higher education provided an important context for investigating the factors influencing students' writing performance. Therefore, this research design was considered suitable for addressing the research objectives and testing the proposed hypotheses.

Participants and Sampling

The participants were undergraduate students enrolled in the Indonesian Language Education Program at Universitas Bosowa, Indonesia. A total of 132 fourth-semester students participated in the study and constituted the final analytical sample. Participants were selected using purposive sampling based on predetermined inclusion criteria. The participants were active fourth-semester students who had received academic writing instruction and had prior experience using generative artificial intelligence tools such as ChatGPT, Gemini, Claude, or Copilot for learning purposes. The selection of fourth-semester students was considered appropriate because they had already received academic writing-related instruction and therefore possessed relevant learning experience for assessing their Academic Writing Skills. In addition, their prior experience with generative AI provided an appropriate context for examining the predictive roles of Artificial Intelligence Literacy and Self-Regulated Learning in academic writing. All 132 participants were included in the statistical analysis.

Data Collection Instruments

Data were collected using two questionnaires and one academic writing assessment task. Artificial Intelligence Literacy was measured through a questionnaire consisting of five dimensions, namely understanding AI concepts, evaluating AI-generated content, ethical use of AI, AI-assisted information retrieval, and effective use of AI tools. Self-Regulated Learning was measured using an instrument adapted from Zimmerman's self-regulation framework, which includes goal setting, strategic planning, self-monitoring, self-evaluation, and time management. Both questionnaires employed a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Academic Writing Skills were assessed through an essay-writing task that required participants to produce an academic text on a topic relevant to contemporary educational issues. The essays were evaluated using an analytic scoring rubric covering organization, content development, academic language use, referencing and citation, and argumentation quality. The combination of questionnaires and performance-based assessment enabled the study to capture both students' perceptions and their actual academic writing performance.

Validity and Reliability

Prior to data collection, all research instruments underwent validity and reliability testing to ensure their suitability for measuring the intended constructs. Content validity was first established through expert judgment involving specialists in educational research, language education, and educational technology. Subsequently, item validity testing was conducted using item-total correlation analysis to determine the adequacy of individual questionnaire items (Hair et al., 2019). The results indicated that all items exceeded the minimum acceptable validity threshold and were therefore retained for further analysis. Reliability was assessed using Cronbach's alpha coefficient, which is widely used to evaluate the internal consistency of research instruments. The obtained alpha coefficients for all variables exceeded the recommended value of 0.70, indicating satisfactory reliability. These findings confirmed that the instruments possessed adequate psychometric properties and were appropriate for use in the present study.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics. Descriptive statistics, including mean scores, standard deviations, minimum values, and maximum values, were calculated to describe the characteristics of the research variables. Before conducting hypothesis testing, several classical assumption tests were performed to ensure the suitability of the regression model. These tests included normality, multicollinearity, heteroscedasticity, and autocorrelation analyses (Field, 2023; Hair et al., 2019). The results of these tests indicated that the data met the assumptions required for multiple linear regression analysis. Multiple linear regression was subsequently employed to examine the individual and simultaneous predictive effects of Artificial Intelligence Literacy and Self-Regulated Learning on Academic Writing Skills. The significance of the regression coefficients, model fit, and coefficient of determination were used as the basis for testing the proposed research hypotheses and interpreting the relationships among the study variables.

RESULTS

1. Descriptive Statistics

Descriptive statistics were conducted to provide an overview of the three main research variables based on the responses of 132 participants. The analysis focused on the mean and standard deviation of Academic Writing Skills, Artificial Intelligence Literacy, and Self-Regulated Learning. The results are presented in Table 1.

Table 1. Descriptive Statistics of the Study Variables

Variable	N	Mean	SD
Academic Writing Skills	132	83.20	8.564
Artificial Intelligence Literacy	132	80.01	8.275
Self-Regulated Learning	132	83.02	8.133

The results show that Academic Writing Skills had the highest mean score (M = 83.20, SD = 8.564), followed by Self-Regulated Learning (M = 83.02, SD = 8.133) and Artificial Intelligence Literacy (M = 80.01, SD = 8.275). The standard deviations indicate a relatively comparable degree of variability across the three variables. These descriptive results provide an initial overview of the participants' scores before examining the relationships and predictive contributions among the variables.

2. Pearson Correlation Analysis

Pearson product-moment correlation analysis was conducted to examine the bivariate relationships among Artificial Intelligence Literacy, Self-Regulated Learning, and Academic Writing Skills. The correlation matrix is presented in Table 2.

Table 2. Pearson Correlations among Study Variables

Variable	1	2	3
Academic Writing Skills	1.000	.590	.506
Artificial Intelligence Literacy	.590	1.000	.525
Self-Regulated Learning	.506	.525	1.000

Note. N = 132. p < 0.001 (1-tailed).

The results indicate a positive correlation between Artificial Intelligence Literacy and Academic Writing Skills (r = .590, p < 0.001). Self-Regulated Learning was also positively correlated with Academic Writing Skills (r = .506, p < 0.001). In addition, Artificial Intelligence Literacy was positively correlated with Self-Regulated Learning (r = .525, p

< 0.001). These findings indicate that the three variables were positively associated with one another. The correlation analysis provides preliminary evidence of the relationships among the variables before their simultaneous contribution was examined through multiple linear regression.

3. Instrument Testing

a. Validity Test

The validity analysis was conducted to determine whether the items used to measure each research variable met the specified item-total correlation criterion. The results of the validity analysis for Artificial Intelligence Literacy, Self-Regulated Learning, and Academic Writing Skills are presented in Table 3.

Table 3. Validity Test Results

Variable	Number of Items	Item-Total Correlation Range	Criterion	Interpretation
Artificial Intelligence Literacy	20	0.421–0.782	> 0.30	Valid
Self-Regulated Learning	20	0.438–0.801	> 0.30	Valid
Academic Writing Skills	5	0.472–0.768	> 0.30	Valid

The results show that all items exceeded the minimum item-total correlation criterion of 0.30. The Artificial Intelligence Literacy items obtained coefficients ranging from 0.421 to 0.782, while the Self-Regulated Learning items ranged from 0.438 to 0.801. The five Academic Writing Skills assessment indicators produced coefficients ranging from 0.472 to 0.768. Therefore, all items met the specified validity criterion and were retained for subsequent analysis.

b. Reliability Test

Following the validity analysis, a reliability test was conducted using Cronbach's alpha to assess the internal consistency of the instruments. The reliability coefficients for the three research variables are presented in Table 4.

Table 4. Reliability Test Results

Artificial Intelligence Literacy	**0.913**	**> 0.70**	**Excellent**
Self-Regulated Learning	0.901	> 0.70	Excellent
Academic Writing Skills	0.887	> 0.70	Good

The results indicate that all three instruments demonstrated satisfactory internal consistency. Artificial Intelligence Literacy obtained a Cronbach's alpha coefficient of 0.913, Self-Regulated Learning obtained 0.901, and Academic Writing Skills obtained 0.887. Because all coefficients exceeded the criterion of 0.70, the instruments were considered sufficiently reliable for the main analysis.

4. Classical Assumption Tests

a. Normality Test

The normality assumption was examined using the histogram and Normal P-P Plot of the standardized regression residuals. These graphical results were used to determine whether the residuals followed an approximately normal distribution. The results are presented in Figure 1.

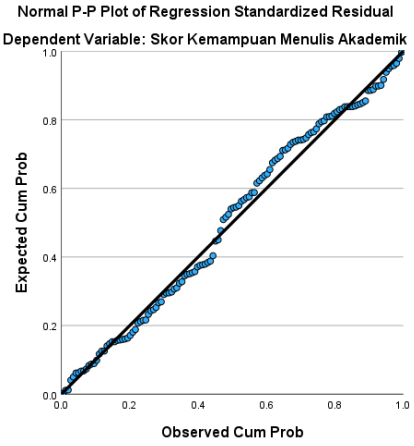


Figure 1. Normal P-P Plot of Regression Standardized Residual

The histogram showed an approximately bell-shaped distribution, while the points in the Normal P-P Plot were distributed around the diagonal reference line. These patterns indicate that the standardized residuals were approximately normally distributed. Therefore, the normality assumption for the multiple regression analysis was considered satisfied.

b. Multicollinearity Test

The multicollinearity assumption was examined using tolerance and variance inflation factor (VIF) values. The results for Artificial Intelligence Literacy and Self-Regulated Learning are presented in Table 5.

Table 5. Multicollinearity Test Results

Variable	Tolerance	VIF
Artificial Intelligence Literacy	0.725	1.380
Self-Regulated Learning	0.725	1.380

Both predictor variables had a tolerance value of 0.725 and a VIF value of 1.380. The tolerance values were above 0.10 and the VIF values were well below the commonly used threshold of 10. These results indicate that no problematic multicollinearity was detected between Artificial Intelligence Literacy and Self-Regulated Learning.

c. Heteroscedasticity Test

The heteroscedasticity assumption was examined using a scatterplot of standardized residuals against predicted values. The results are presented in Figure 2.

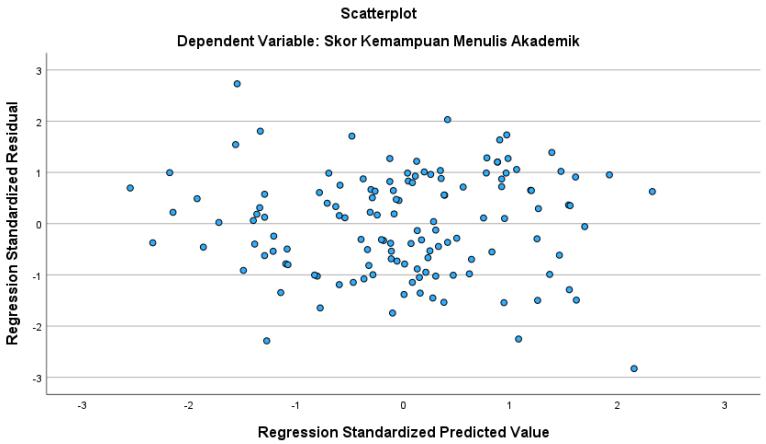


Figure 2. Scatterplot of Standardized Residuals

The residual points were distributed around the zero line without a clear systematic or funnel-shaped pattern. This distribution suggests that the variance of the residuals was relatively constant across the predicted values. Therefore, no apparent heteroscedasticity problem was identified in the regression model.

d. Independence of Errors

The independence of errors was examined using the Durbin-Watson statistic obtained from the regression analysis. The resulting Durbin-Watson value was 1.779. The value of 1.779 indicates that the residuals did not show an apparent autocorrelation problem. Therefore, the independence of errors assumption was considered satisfactory for the regression analysis.

5. Multiple Linear Regression Analysis

a. Model Summary

Multiple linear regression analysis was conducted to examine the simultaneous predictive contribution of Artificial Intelligence Literacy and Self-Regulated Learning to Academic Writing Skills. The overall model summary is presented in Table 6.

Table 6. Multiple Linear Regression Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Durbin-Watson
1	.634	.402	.392	6.676	1.779

Note. Predictors: (Constant), Artificial Intelligence Literacy, Self-Regulated Learning. Dependent Variable: Academic Writing Skills. N = 132.

The model produced an R value of .634, indicating a positive overall association between the predictors and Academic Writing Skills. The R^2 value of .402 indicates that Artificial Intelligence Literacy and Self-Regulated Learning jointly explained 40.2% of the variance in Academic Writing Skills. The adjusted R^2 was .392, indicating that the model explained 39.2% of the variance after adjustment for the number of predictors. The standard error of the estimate was 6.676.

b. Regression Coefficients

The individual predictive contributions of Artificial Intelligence Literacy and Self-Regulated Learning were examined using the regression coefficients, t-values, significance levels, and 95% confidence intervals. The results are presented in Table 7.

Table 7. Multiple Linear Regression Coefficients

Predictor	B	SE	β	t	p	95% CI
Constant	22.414	6.673	—	3.359	0.001	[9.212, 35.616]
Artificial Intelligence Literacy	.463	.083	.448	5.595	< 0.001	[.299, .627]
Self-Regulated Learning	.286	.084	.271	3.392	< 0.001	[.119, .452]

Note. Dependent Variable: Academic Writing Skills. N = 132.

The results show that Artificial Intelligence Literacy had a positive and statistically significant predictive contribution to Academic Writing Skills ($\beta = 0.448$, $t = 5.595$, $p < 0.001$). The 95% confidence interval for the unstandardized coefficient ranged from .299 to .627, indicating a positive coefficient across the estimated interval.

Self-Regulated Learning also had a positive and statistically significant predictive contribution to Academic Writing Skills ($\beta = 0.271$, $t = 3.392$, $p < 0.001$). Its 95% confidence interval ranged from .119 to .452. The standardized coefficient for Artificial Intelligence Literacy was higher than that for Self-Regulated Learning, indicating a stronger standardized predictive contribution of Artificial Intelligence Literacy within the regression model. Based on the unstandardized coefficients, the multiple regression equation was:

$$Y = 22.414 + 0.463X_1 + 0.286X_2$$

where Y represents Academic Writing Skills, X_1 represents Artificial Intelligence Literacy, and X_2 represents Self-Regulated Learning.

6. Hypothesis Testing

a. Partial Significance Tests: H1 and H2

The first and second hypotheses were tested using the partial t-tests obtained from the multiple regression model. The results of the hypothesis tests are summarized in Table 8.

Table 8. Partial Significance Tests for H1 and H2

Hypothesis	Predictor	β	t	p	Decision
H1	Artificial Intelligence Literacy	.448	5.595	< 0.001	Supported
H2	Self-Regulated Learning	.271	3.392	< 0.001	Supported

The results indicate that Artificial Intelligence Literacy significantly predicted Academic Writing Skills ($\beta = 0.448$, $t = 5.595$, $p < 0.001$). Therefore, H1 was supported. Self-Regulated Learning also significantly predicted Academic Writing Skills ($\beta = 0.271$, $t = 3.392$, $p < 0.001$), resulting in support for H2. Among the two predictors, Artificial Intelligence Literacy demonstrated the larger standardized regression coefficient ($\beta = 0.448$) compared with Self-Regulated Learning ($\beta = 0.271$).

b. Simultaneous Significance Test: H3

The third hypothesis examined whether Artificial Intelligence Literacy and Self-Regulated Learning jointly provided a significant prediction of Academic Writing Skills. The simultaneous significance of the regression model was assessed using the F-test. The ANOVA results are presented in Table 9.

Table 9. ANOVA Results for the Multiple Regression Model

Model	Sum of Squares	df	Mean Square	F	p
Regression	3857.743	2	1928.872	43.276	< 0.001
Residual	5749.734	129	44.572	—	—
Total	9607.477	131	—	—	—

Note. Dependent Variable: Academic Writing Skills. Predictors: Artificial Intelligence Literacy and Self-Regulated Learning. N = 132.

The ANOVA results indicate that the overall regression model was statistically significant, $F(2, 129) = 43.276$, $p < 0.001$. This finding demonstrates that Artificial Intelligence Literacy and Self-Regulated Learning jointly provided a significant prediction of Academic Writing Skills. Therefore, H3 was supported.

c. Coefficient of Determination

The coefficient of determination was interpreted based on the R^2 value reported in the regression model. The R^2 value of 0.402 indicates that Artificial Intelligence Literacy and Self-Regulated Learning jointly explained 40.2% of the variance in Academic Writing Skills. The remaining 59.8% of the variance was associated with other factors that were not included in the present regression model. The adjusted R^2 value of .392 indicates that the explanatory proportion remained 39.2% after adjustment for the number of predictors in the model.

DISCUSSION

1. The Predictive Role of Artificial Intelligence Literacy in Academic Writing Skills

The first hypothesis was supported, indicating that Artificial Intelligence Literacy significantly predicted Academic Writing Skills among fourth-semester students in the Indonesian Language Education Program at Universitas Bosowa ($\beta = 0.448$, $t = 5.595$, $p < 0.001$). The positive standardized coefficient indicates that students with higher levels of AI literacy tended to demonstrate higher academic writing performance when Self-Regulated Learning was controlled in the regression model. Among the two predictors examined, Artificial Intelligence Literacy demonstrated the stronger standardized predictive contribution. This finding suggests that students' ability to understand and critically engage with artificial intelligence is relevant to their academic writing development in an increasingly AI-mediated higher education environment. However, because the study employed a predictive correlational design, the result should be interpreted as a significant predictive relationship rather than evidence of a causal effect.

The positive relationship can be explained by the multidimensional nature of AI literacy. AI literacy involves not only the ability to operate AI applications but also the ability to understand AI-generated information, evaluate its accuracy and relevance, recognize its limitations, and use AI responsibly (Karaduman, 2025; Nabhan & Habók, 2026; Sevimel-Sahin & Sahin, 2026). These competencies are directly relevant to academic writing because students must select appropriate information, evaluate sources, develop arguments, and make decisions about which information should be incorporated into their texts. Students with stronger AI literacy may therefore be more capable of treating AI as a supporting resource rather than as a substitute for their own academic reasoning. This interpretation is consistent with research indicating that AI literacy is associated with more strategic engagement with AI-supported learning activities (Drajati et al., 2025; Shi et al., 2025; Wang et al., 2025).

The present finding is also consistent with research showing that AI-supported technologies can facilitate different stages of academic writing. AI tools may assist students in generating ideas, organizing content, refining language, and receiving immediate feedback (Utami & Winarni, 2023; Zhou et al., 2025). However, the current finding extends this literature by emphasizing AI literacy rather than AI use itself. Students who simply use generative AI frequently may not necessarily develop stronger writing skills, particularly when they accept AI-generated information without verification. AI literacy provides an additional layer of competence because it enables students to judge the usefulness and limitations of AI-generated outputs before incorporating them into academic writing. Therefore, the positive predictive contribution found in this study may reflect the importance of informed and critical AI engagement rather than the amount of AI use.

At the same time, the positive finding needs to be considered alongside studies that have reported concerns about excessive dependence on AI. Octaberlina et al. (2024) and Qoyyimah & Bargallie (2025) have highlighted concerns regarding originality, critical thinking, and inappropriate reliance on AI-generated content in academic writing. These findings do not necessarily contradict the present result because AI literacy and AI overreliance represent different forms of engagement with artificial intelligence. AI overreliance may occur when students accept automated outputs without sufficient evaluation, whereas AI literacy involves the capacity to assess, regulate, and use AI appropriately. The present result therefore suggests that developing AI literacy may be one way to address some of the risks associated with generative AI rather than an argument for unrestricted AI use.

The finding has important implications for academic writing instruction in Indonesian Language Education. Rather than simply introducing students to generative AI applications, lecturers can develop activities that require students to verify AI-generated claims, compare AI outputs with scholarly sources, identify inaccuracies, and revise AI-assisted text using their own reasoning. Such activities can strengthen students' ability to maintain authorship and originality while benefiting from technological support. The findings also suggest that AI literacy should be positioned as part of academic and digital literacy rather than as a purely technical skill. For pre-service Indonesian language teachers, this competency is particularly important because they will eventually be expected to guide their own students in using digital and AI technologies critically and responsibly.

2. The Predictive Role of Self-Regulated Learning in Academic Writing Skills

The second hypothesis was supported, showing that Self-Regulated Learning significantly predicted Academic Writing Skills ($\beta = 0.271$, $t = 3.392$, $p < 0.001$). Although the standardized coefficient was smaller than that of Artificial Intelligence Literacy, the positive coefficient indicates that Self-Regulated Learning made an independent contribution to academic writing performance when both predictors were considered simultaneously. This finding indicates that students' ability to regulate their own learning remains important even when academic writing takes place in an environment supported by generative AI. Academic writing requires students to manage multiple processes, including planning, organizing ideas, drafting, revising, and evaluating their final texts. Therefore, students who are able to regulate these processes may be better positioned to complete complex writing tasks effectively.

The predictive contribution of Self-Regulated Learning can be understood through its cognitive, metacognitive, and behavioral dimensions. Goal setting helps students determine what they need to accomplish, while strategic planning enables them to organize the steps required to complete a writing task. Self-monitoring allows students to identify weaknesses during the writing process, whereas self-evaluation enables them to judge the quality of the completed text and determine whether further revision is necessary. Time management also becomes important because academic writing often requires sustained effort across several stages. Previous research has similarly shown that self-regulated writing strategies are associated with stronger writing achievement and engagement (Teng & Zhang, 2020; Umamah & Cahyono, 2020).

The present result is further supported by studies conducted in technology-enhanced learning environments. Jin et al. (2025) found that self-regulatory competence was important in AI-supported learning because students needed to manage their engagement with technological resources rather than passively receive automated assistance. X. Wang et al. (2025) also reported a positive relationship between self-regulated writing strategies and academic writing performance, while Zhang & Liang (2026) emphasized the role of self-regulation in enabling students to engage productively with chatbot-assisted writing scaffolds. These findings suggest that technological support does not eliminate the need for learner autonomy. Instead, students' ability to regulate their own learning may influence how effectively they use available technological resources.

Nevertheless, the findings should not be interpreted as indicating that Self-Regulated Learning alone determines academic writing performance. The regression model explained 40.2% of the variance in Academic Writing Skills, meaning that a substantial proportion remained unexplained by AI Literacy and SRL. Other factors, such as language proficiency, prior writing experience, academic motivation, self-efficacy, instructional practices, and feedback, may also influence writing performance. Research has shown that metacognitive processes and learner characteristics are associated with academic writing development (Hwang, 2025; Prihandoko et al., 2024). Thus, the contribution of SRL identified in the present study should be understood as one important component within a broader system of factors associated with academic writing.

The practical implication is that academic writing instruction should deliberately cultivate self-regulatory behaviors rather than focusing exclusively on the final written product. Lecturers can incorporate writing plans, goal-setting activities, progress monitoring, reflective journals, self-assessment, peer feedback, and structured revision activities. In AI-supported writing environments, these strategies can be combined with reflection on students' decisions concerning AI use. For example, students can be asked to explain why they accepted or rejected particular AI-generated suggestions and how they verified information obtained from AI tools. Such practices may help students retain control over their writing process while using AI as a supporting resource.

3. The Joint Predictive Contribution of Artificial Intelligence Literacy and Self-Regulated Learning

The third hypothesis was supported because Artificial Intelligence Literacy and Self-Regulated Learning jointly provided a statistically significant prediction of Academic Writing Skills, $F(2, 129) = 43.276$, $p < 0.001$. The regression model produced $R = 0.634$ and $R^2 = 0.402$, indicating that the two predictors jointly explained 40.2% of the variance in Academic Writing Skills. The adjusted R^2 was 0.392, indicating that the model retained a meaningful explanatory

contribution after adjustment for the number of predictors. These results demonstrate that AI Literacy and SRL provide complementary predictive information regarding students' academic writing performance.

The complementary contribution of the two predictors can be understood from the different functions of each construct. AI Literacy concerns students' capacity to understand, evaluate, and use AI technologies responsibly, whereas Self-Regulated Learning concerns their ability to plan, monitor, control, and evaluate their own learning processes. A student may have sufficient knowledge about AI but still use AI-generated content uncritically if the student lacks adequate self-regulatory control. Conversely, a highly self-regulated student may organize the writing process effectively but may have difficulty evaluating AI-generated information without sufficient AI literacy. Research has increasingly linked AI literacy and self-regulated learning within technology-enhanced learning environments (Nabhan & Habók, 2026; Shi et al., 2025; (Wang et al., 2025). The simultaneous significance of both predictors in the present study provides empirical support for considering technological competence and learner regulation as complementary dimensions of AI-supported academic writing.

The correlation results provide additional context for interpreting this joint contribution. Artificial Intelligence Literacy was positively correlated with Academic Writing Skills ($r = 0.590$, $p < 0.001$), while Self-Regulated Learning was also positively correlated with Academic Writing Skills ($r = 0.506$, $p < 0.001$). The two predictor variables were positively correlated with each other ($r = 0.525$, $p < 0.001$), but the tolerance value of 0.725 and VIF value of 1.380 indicated that their relationship did not create problematic multicollinearity. Thus, although students with higher AI literacy also tended to report higher self-regulated learning, the two constructs remained sufficiently distinct to make separate predictive contributions to Academic Writing Skills.

The present finding should be interpreted in relation to previous studies that have already examined relationships among AI literacy, self-regulated learning, and technology-supported writing. Research by Jin et al. (2025), Pan & Zhang (2026), Shi et al. (2025), and Wang et al. (2025) demonstrates that these constructs have been considered in related AI-assisted learning and writing contexts. Therefore, the present study does not claim that the simultaneous examination of AI Literacy and SRL is entirely new. Instead, its contribution lies in examining their predictive roles among fourth-semester students in an Indonesian Language Education Program at Universitas Bosowa and specifically in relation to Academic Writing Skills. This population and contextual focus provides evidence from an Indonesian teacher-education setting that is less represented in the existing literature, much of which has focused on EFL, L2 writing, or broader higher education contexts.

The R^2 value of .402 also provides an important qualification to the joint contribution. Although AI Literacy and SRL explained 40.2% of the variance in Academic Writing Skills, 59.8% remained unexplained by the current model. This finding confirms that academic writing is multidimensional and cannot be adequately understood through technological literacy and self-regulation alone. Previous research has identified additional factors related to writing outcomes, including self-efficacy, metacognition, writing strategies, and learner engagement (Hwang, 2025; Prihandoko et al., 2024; Teng & Zhang, 2020). Future research could therefore extend the model by incorporating these variables and examining whether their inclusion improves the explanatory power of the model.

4. Theoretical and Practical Implications

The findings provide theoretical support for understanding academic writing in AI-mediated higher education as a competence involving both technological and self-regulatory dimensions. AI Literacy provides students with the knowledge and evaluative capacity required to interact critically with AI-generated information, while Self-Regulated Learning provides the mechanisms needed to plan, monitor, and evaluate their own learning activities. The significant contribution of both predictors suggests that responsible AI-supported writing requires more than technological access or technical familiarity. It requires students to exercise judgment and maintain control over their learning and writing processes. This interpretation is consistent with the growing emphasis on responsible AI competence, critical engagement, and learner autonomy in higher education (Ilma & Rohmah, 2025; Karaduman, 2025).

The stronger standardized coefficient for AI Literacy ($\beta = 0.448$) compared with SRL ($\beta = 0.271$) suggests that AI Literacy had a greater predictive contribution within the present model. However, this difference should not be generalized as evidence that AI Literacy is universally more important than Self-Regulated Learning. The relative contribution may be influenced by the characteristics of the participants, the academic context, and the specific measurement instruments used in the study. Because all participants were fourth-semester students who had already received academic writing instruction and had experience with generative AI, AI-related competencies may have been particularly relevant to their academic writing activities. Therefore, the relative strength of the predictors should be interpreted within the boundaries of the present sample and research context.

From a practical perspective, the findings suggest that teacher education programs should integrate AI literacy and self-regulated learning into academic writing instruction rather than treating them as separate competencies. Students can be trained to formulate writing goals, plan arguments, use AI selectively, verify AI-generated information, monitor their progress, and critically evaluate their final texts. Such integration can help students benefit from AI-assisted writing while maintaining academic integrity, originality, and independent reasoning. Previous research has similarly emphasized the importance of developing critical and responsible AI use alongside students' broader learning competencies (Castillo-Cuesta et al., 2025; Ilma & Rohmah, 2025; Kohnke & Green-Eneix, 2025).

For Indonesian Language Education programs, these implications are particularly relevant because pre-service teachers will eventually influence how their own students engage with digital technologies. Academic writing courses can therefore serve as an important context for developing responsible AI practices through activities such as AI-output verification, source comparison, reflective writing, revision documentation, and evaluation of AI-generated suggestions. Rather than encouraging students to maximize their use of generative AI, instruction should emphasize appropriate, critical, ethical, and self-regulated use. Such an approach may help future Indonesian language teachers develop both the technological competence and learner autonomy necessary to navigate AI-mediated educational environments responsibly.

CONCLUSION

This study concludes that Artificial Intelligence Literacy and Self-Regulated Learning are important predictors of Academic Writing Skills among students in the Indonesian Language Education Program. The findings indicate that students' ability to understand, evaluate, and use artificial intelligence responsibly is associated with stronger academic writing performance, while the ability to regulate learning through goal setting, planning, monitoring, and self-evaluation also contributes to writing development. The findings further suggest that technological competence and self-regulatory competence should be viewed as complementary dimensions of academic writing in AI-mediated learning environments. Rather than encouraging dependence on generative AI, academic writing instruction should emphasize critical evaluation, responsible use of AI, learner autonomy, and students' ownership of the writing process.

The findings have practical implications for Indonesian Language Education programs, particularly in designing academic writing instruction that integrates responsible AI literacy with self-regulated learning strategies. Students should be encouraged to verify AI-generated information, evaluate sources, maintain originality, establish writing goals, monitor their progress, and critically evaluate their final texts. However, the use of purposive sampling and participants from a single university and academic semester limits the transferability of the findings to other educational contexts. Future research should therefore involve more diverse institutions and student cohorts and examine additional factors, such as writing self-efficacy, language proficiency, prior writing experience, motivation, and instructional practices, to provide a broader understanding of academic writing in AI-mediated learning environments.

LIMITATIONS

This study has several limitations. The use of purposive sampling and participants from a single university and academic semester limits the generalizability of the findings to other institutions and student populations. In addition, Artificial Intelligence Literacy and Self-Regulated Learning were measured using self-report instruments, while Academic Writing Skills were assessed through a single writing task, which may not fully capture students' competencies across different contexts. The cross-sectional design also limits causal interpretation of the relationships among the variables. Future research should therefore involve larger and more diverse samples, multiple writing tasks, and longitudinal or experimental designs to provide broader evidence regarding AI literacy, self-regulated learning, and academic writing.

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AUTHOR CONTRIBUTION STATEMENT

VA, A, AH, and NL jointly conceptualized the study and developed the research design. VA conducted the literature review, collected the data, performed the statistical analyses, interpreted the findings, and prepared the initial manuscript draft. A, AH, and NL supervised the research process, contributed to the interpretation of the results, critically reviewed and revised the manuscript for important intellectual content, and approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

AI DISCLOSURE STATEMENT

The authors used AI during the preparation of this manuscript to assist with language refinement, grammar improvement, and manuscript organization. After using the tool, the authors carefully reviewed, verified, and edited all content and take full responsibility for the accuracy, originality, and integrity of the published work.

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