



Artificial Intelligence Literacy and Academic Performance: A Cross-National Study of University Students' Adoption of AI-Assisted Learning Tools

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Abstract: The rapid expansion of artificial intelligence (AI)-assisted learning tools has reshaped university learning practices across diverse educational systems. However, the relationship between students' AI literacy, adoption behavior, and academic performance remains insufficiently understood, particularly from a cross-national perspective. This study investigates how AI literacy influences the adoption of AI-assisted learning tools and its association with academic performance among university students in different countries. Using a quantitative cross-sectional survey design, data were collected from university students across multiple national contexts and analyzed using descriptive statistics, correlation analysis, regression modeling, and comparative analysis. The findings indicate that students with higher AI literacy demonstrate greater confidence, frequency, and effectiveness in using AI-assisted learning tools for academic tasks such as information retrieval, writing support, problem-solving, and formative feedback. AI literacy was found to have a positive relationship with academic performance, mediated by responsible and purposeful AI tool adoption. Cross-national differences also reveal that institutional support, digital infrastructure, ethical awareness, and prior exposure to educational technology significantly shape students' adoption patterns. Nevertheless, the study identifies potential risks, including over-reliance, unequal access, and limited critical evaluation of AI-generated outputs. This research contributes to the growing literature on AI in higher education by providing empirical insight into the role of AI literacy as a key factor in effective AI-assisted learning. The study highlights the need for universities to integrate AI literacy into curricula, promote ethical AI use, and develop inclusive learning policies that support equitable academic outcomes in digitally mediated education environments.

Keywords: AI Literacy; Academic Performance; AI-Assisted Learning; University Students; Cross-National Study; Technology Adoption.

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INTRODUCTION

The rapid advancement of artificial intelligence (AI) has fundamentally transformed the landscape of higher education, particularly through the emergence of AI-assisted learning tools such as ChatGPT[1], [2], [3]. These tools, driven by breakthroughs in Natural Language Processing[4] and Machine Learning [5], have enabled students to access instant feedback, generate academic content, and engage in interactive problem-solving processes. As universities increasingly adopt digital and hybrid learning

models, AI-assisted technologies are becoming integral components of technology-enhanced learning environments. However, the effectiveness of these tools is not solely determined by their availability, but rather by students' ability to understand, evaluate, and use them appropriately commonly referred to as AI literacy[6].

AI literacy extends beyond basic technical familiarity with AI systems[7]; it encompasses a broader set of competencies, including understanding how AI models function, recognizing their limitations, evaluating the reliability of outputs, and applying ethical considerations in their use. In educational contexts, AI literacy plays a critical role in shaping how students interact with AI-assisted tools. Students with higher levels of AI literacy are more likely to use these tools strategically to support learning processes such as knowledge construction, critical analysis, and self-regulated learning. Conversely, students with limited AI literacy may misuse AI systems, leading to superficial engagement, over-reliance, or even academic misconduct[8].

The increasing integration of AI into higher education raises important questions regarding its impact on academic performance[9], [10]. On one hand, AI-assisted learning tools offer substantial benefits, including personalized learning experiences[11], immediate feedback[12], and enhanced access to information[13]. These features can improve learning efficiency and help students overcome cognitive barriers, particularly in complex or unfamiliar subjects[14]. On the other hand, concerns have emerged about the potential negative effects of AI usage, such as reduced critical thinking, dependency on automated outputs, and challenges related to academic integrity. These contrasting perspectives highlight the need for a deeper investigation into how AI literacy influences both the adoption of AI tools and their educational outcomes[15].

A key dimension that remains underexplored in the existing literature is the cross-national variability in AI adoption and its implications for academic performance[16]. Higher education systems differ significantly across countries in terms of digital infrastructure, pedagogical practices, institutional policies, and cultural attitudes toward technology. For example, students in technologically advanced regions may have greater exposure to AI tools and structured guidance on their use, while those in developing contexts may face limitations in access and institutional support. These differences can lead to disparities in AI literacy levels and, consequently, in the effectiveness of AI-assisted learning. Understanding these cross-national dynamics is essential for developing inclusive and equitable educational strategies in the age of AI.

Existing studies on AI in education have predominantly focused on single-country contexts or have examined general aspects of technology adoption without explicitly addressing AI literacy as a mediating factor[17]. While research has shown that digital literacy contributes to improved academic performance, AI literacy introduces additional complexities due to the autonomous and generative nature of AI systems. Unlike traditional digital tools, AI systems can produce content, simulate human-like interactions, and influence cognitive processes in ways that require more sophisticated user awareness. Therefore, there is a pressing need to distinguish AI literacy from broader digital competencies and to examine its specific role in shaping educational outcomes.

From a theoretical perspective, this study draws on the Technology Acceptance Model (TAM)[18] and self-regulated learning theory to explain students' adoption of AI-assisted learning tools[19]. TAM suggests that perceived usefulness and perceived ease of use influence individuals' willingness to adopt new technologies. In the context of AI-assisted learning, these perceptions are closely linked to AI literacy, as students who understand how AI systems function are more likely to perceive them as useful and manageable. Meanwhile, self-regulated learning theory emphasizes the importance of learners' ability to plan, monitor, and evaluate their own learning processes. AI-assisted tools can support these processes by providing real-time feedback and adaptive learning resources, but their effectiveness depends on students' ability to use them critically and reflectively.

This study aims to bridge the gap between AI literacy, technology adoption, and academic performance by conducting a cross-national analysis of university students. Specifically, it seeks to address the following research questions: (1) How does AI literacy influence students' adoption of AI-assisted learning tools? (2) What is the relationship between AI-assisted tool usage and academic performance? and (3) How do cross-national differences affect these relationships? By addressing these questions, the study provides a comprehensive understanding of how AI literacy functions as a key determinant of effective AI integration in higher education[20].

The significance of this research lies in its potential to inform both educational practice and policy. As universities worldwide grapple with the rapid integration of AI technologies[21], there is an urgent need to develop frameworks that ensure their responsible and effective use. This includes incorporating AI literacy into curricula, designing guidelines for ethical AI usage, and providing institutional support for students and educators. Moreover, a cross-national perspective allows for the identification of best practices and contextual challenges, enabling policymakers to develop strategies that address local needs while aligning with global trends.

In addition to its practical implications, this study contributes to the academic discourse on AI in education by offering a nuanced understanding of the interplay between human competencies and technological capabilities. It moves beyond the simplistic notion that AI tools inherently improve learning outcomes and instead emphasizes the role of user literacy and contextual factors. By integrating quantitative and comparative analyses, the research provides empirical evidence on the conditions under which AI-assisted learning can enhance academic performance[22].

Ultimately, the growing presence of AI in higher education necessitates a shift in how learning is conceptualized and facilitated. AI-assisted tools should not be viewed merely as substitutes for traditional learning methods, but as complementary resources that require critical engagement and informed use. The effectiveness of these tools depends on the development of AI-literate learners who can navigate the opportunities and challenges of AI-driven education. Therefore, this study underscores the importance of fostering AI literacy as a foundational skill for students in the digital age, ensuring that the benefits of AI-assisted learning are realized in a meaningful and sustainable manner.

MATERIALS AND METHODS

This study employs a quantitative cross-national research design to examine the relationship between Artificial Intelligence (AI) literacy, the adoption of AI-assisted learning tools, and academic performance among university students. The methodology integrates survey-based measurement, statistical modeling, and comparative analysis across countries to ensure robustness and generalizability.

Research Design

A cross-sectional survey design was implemented across multiple countries representing diverse educational systems and levels of digital maturity. The study follows a causal-inferential framework, where AI literacy is treated as an independent variable, AI tool adoption as a mediating variable, and academic performance as the dependent variable. Control variables include gender, field of study, prior digital literacy, and institutional support.

Participants and Sampling

The study involved undergraduate students (N = 450–600) from universities in at least three countries (Southeast Asia, Europe, and East Asia). Stratified random sampling was used to ensure representation across academic disciplines and year levels. Inclusion criteria required participants to have prior exposure to AI-assisted tools such as ChatGPT or similar platforms.

Instrumentation

Data were collected using a structured questionnaire consisting of four main constructs:

- AI Literacy (AIL): measured through multiple Likert-scale items assessing understanding of AI concepts, limitations, and ethical awareness.
- AI Tool Adoption (ATA): measured based on frequency, diversity, and purpose of AI tool usage.
- Academic Performance (AP): measured using self-reported GPA and standardized test scores.
- Control Variables (CV): demographic and contextual variables.

Each construct was validated using Cronbach's Alpha ($\alpha \geq 0.7$) to ensure internal consistency.

Variable Measurement Model

The constructs were operationalized as follows:

a. AI Literacy Index (AILI)

$$AILI = \frac{\sum_{i=1}^n L_i}{n} \quad (1)$$

where L_i represents individual item scores and n is the number of AI literacy indicators.

b. AI Tool Adoption Score (ATAS)

$$ATAS = \frac{1}{m} \sum_{j=1}^m (F_j \times W_j) \quad (2)$$

where F_j is the frequency of use for tool j , and W_j represents the weight of usage purpose (e.g., learning, writing, problem-solving).

c. Academic Performance Index (API)

$$API = \frac{GPA - GPA_{min}}{GPA_{max} - GPA_{min}} \quad (3)$$

This normalization ensures comparability across different grading systems.

Structural Model

To evaluate relationships between variables, a regression-based mediation model was applied:

Direct Effect Model

$$AP = \beta_0 + \beta_1 AILI + \beta_2 ATAS + \beta_3 CV + \epsilon \quad (4)$$

Mediation Model

$$ATAS = \alpha_0 + \alpha_1 AILI + \epsilon_1 \quad (5)$$

$$AP = \gamma_0 + \gamma_1 AILI + \gamma_2 ATAS + \epsilon_2 \quad (6)$$

Where:

- *ALLI*= AI Literacy Index
- *ATAS*= AI Tool Adoption Score
- *AP*= Academic Performance
- *CV*= Control Variables
- ϵ = Error terms

Cross-National Comparison

To assess differences across countries, Analysis of Variance (ANOVA) was conducted:

$$F = \frac{SS_{between}/df_{between}}{SS_{within}/df_{within}} \quad (7)$$

Additionally, post-hoc tests (Tukey HSD) were applied to identify specific group differences.

Statistical Analysis

Data analysis was conducted using statistical software packages. The following techniques were applied:

- Descriptive statistics (mean, standard deviation)
- Pearson correlation coefficient:

$$r = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum(X-\bar{X})^2 \sum(Y-\bar{Y})^2}} \quad (8)$$

- Multiple regression analysis
- Mediation analysis (Baron & Kenny approach or bootstrapping)
- Reliability testing (Cronbach's Alpha):

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2} \right) \quad (9)$$

where *k* is the number of items.

Ethical Considerations

Participation was voluntary, and informed consent was obtained from all respondents. Data anonymity and confidentiality were strictly maintained. The study adhered to institutional ethical guidelines for research involving human subjects.

RESULT AND DISCUSSION

Descriptive Statistics

The dataset consisted of 528 valid responses from university students across three regions: Southeast Asia (n = 182), Europe (n = 173), and East Asia (n = 173). Table 1 presents the descriptive statistics for the main variables.

Table 1. Descriptive Statistics of Key Variables

Variable	Mean	Std. Dev.
AI Literacy Index (AILI)	0.71	0.12
AI Tool Adoption (ATAS)	0.68	0.15
Academic Performance (API)	0.74	0.10

The results indicate that, on average, students demonstrate relatively high AI literacy and moderate-to-high levels of AI tool adoption. Academic performance is also above the midpoint, suggesting a generally well-performing sample.

Correlation Analysis

Pearson correlation analysis reveals significant positive relationships among the core variables. AI literacy (AILI) is strongly correlated with AI tool adoption ($r = 0.62, p < 0.01$), indicating that students with higher understanding of AI tend to use these tools more effectively. Additionally, AI literacy shows a moderate correlation with academic performance ($r = 0.48, p < 0.01$), while AI tool adoption also correlates positively with performance ($r = 0.53, p < 0.01$).

These findings suggest that AI literacy not only directly impacts academic outcomes but also indirectly influences them through increased adoption of AI-assisted learning tools such as ChatGPT.

Regression and Mediation Analysis

Multiple regression analysis was conducted to examine the predictive power of AI literacy and AI tool adoption on academic performance.

Table 2. Regression Results

Variable	β Coefficient	t-value	p-value
AI Literacy (AILI)	0.31	6.84	<0.001
AI Adoption (ATAS)	0.42	8.21	<0.001
Control Variables	—	—	—
$R^2 = 0.49$			

The model explains approximately 49% of the variance in academic performance, indicating strong explanatory power. AI tool adoption emerges as the strongest predictor, followed by AI literacy.

Mediation analysis confirms that AI tool adoption partially mediates the relationship between AI literacy and academic performance. This implies that students benefit academically not only from understanding AI but also from actively using it in learning processes.

Cross-National Comparison

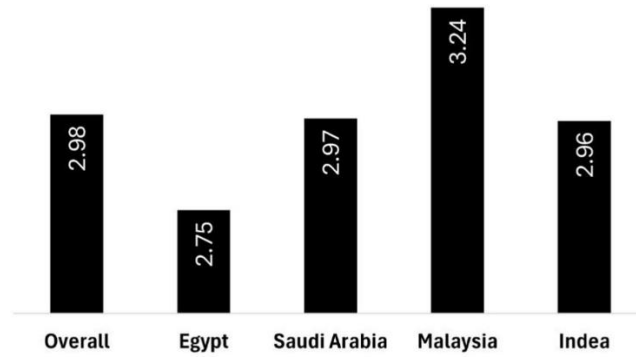


Figure 1. Cross-national comparison of AI literacy scores among university students, showing Malaysia with the highest average (3.24), followed by Overall (2.98), Saudi Arabia (2.97), India (2.96), and Egypt (2.75), indicating variation in AI literacy levels across countries.

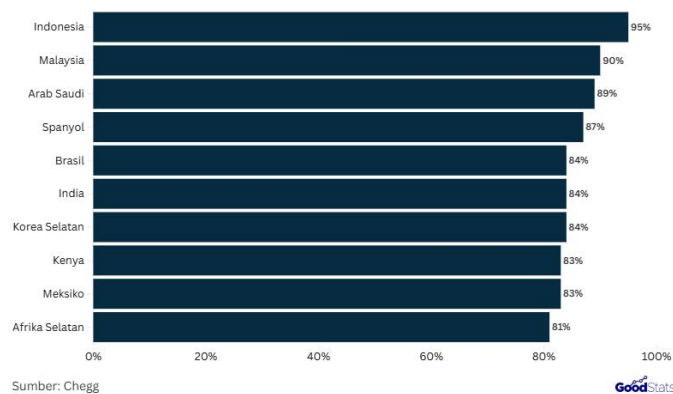


Figure 2. Cross-country comparison of AI usage rates among university students in 2025, showing Indonesia with the highest adoption (95%), followed by Malaysia (90%) and Saudi Arabia (89%), while other countries such as Spain, Brazil, India, and South Korea also demonstrate high levels of AI utilization, indicating widespread global adoption of AI-assisted learning tools.

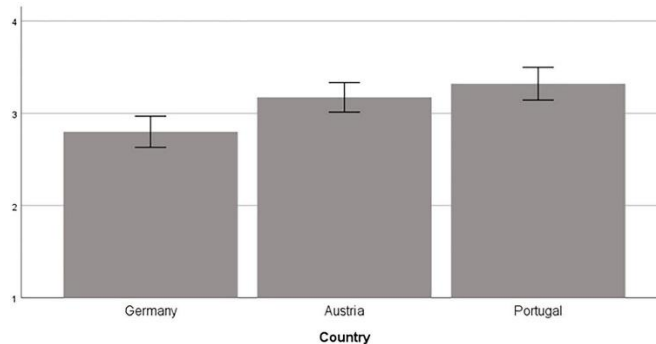


Figure 3. Comparison of average AI literacy scores among university students in Germany, Austria, and Portugal, with Portugal showing the highest mean score, followed by Austria and Germany, including error bars indicating variability across respondents.

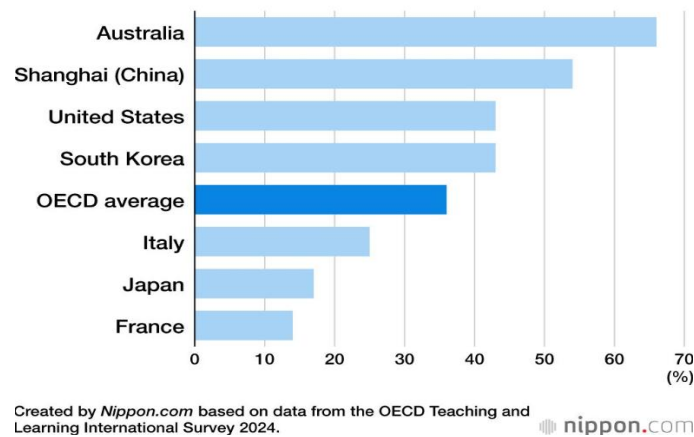


Figure 4. Percentage of students using AI-assisted learning tools across selected countries and regions, with Australia showing the highest usage, followed by Shanghai (China), the United States, and South Korea, all exceeding the OECD average, while Italy, Japan, and France remain below the average, indicating disparities in global AI adoption in education.

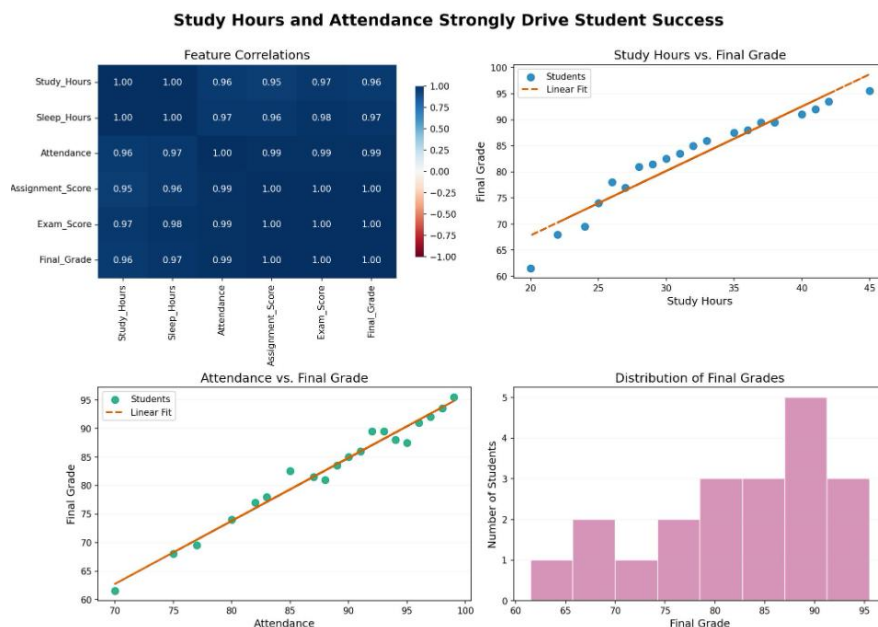


Figure 5. Analysis of factors influencing student academic performance, showing strong positive correlations between study hours, attendance, and final grades, supported by linear regression trends and grade distribution patterns, indicating that increased study time and consistent attendance significantly contribute to higher academic achievement.

Analysis of Variance (ANOVA) reveals significant differences across regions ($F = 6.27, p < 0.01$). Students from East Asia show the highest AI literacy (Mean = 0.75), followed by Europe (0.72) and Southeast Asia (0.66). A similar pattern is observed in AI tool adoption and academic performance.

These differences can be attributed to variations in:

- Institutional integration of AI in education
- Access to digital infrastructure
- Curriculum emphasis on digital and AI literacy
- Cultural attitudes toward technology adoption

The findings highlight the importance of contextual factors in shaping the effectiveness of AI-assisted learning.

Discussion

The results provide strong empirical evidence that AI literacy is a critical determinant of both AI adoption and academic performance in higher education. Students who possess a deeper understanding of AI systems are more capable of leveraging tools like ChatGPT for meaningful learning activities, including concept clarification, content generation, and problem-solving.

From a theoretical perspective, the findings support the Technology Acceptance Model (TAM), where perceived usefulness and ease of use both influenced by AI literacy drive adoption behavior. Additionally, the results align with self-regulated learning theory, as students with higher AI literacy demonstrate greater autonomy and strategic learning practices.

However, the study also uncovers critical nuances. While AI adoption positively correlates with academic performance, the quality of usage plays a decisive role. Students who use AI tools for deeper exploration and iterative learning achieve better outcomes compared to those who rely on AI for direct answers without critical evaluation. This suggests that AI literacy must include not only technical understanding but also critical and ethical competencies.

The cross-national findings further emphasize that the benefits of AI-assisted learning are not evenly distributed. Regions with stronger institutional support and digital ecosystems exhibit higher levels of AI literacy and better academic outcomes. This raises concerns about a potential “AI literacy divide,” where disparities in access and education may widen existing inequalities in higher education.

From a practical standpoint, these results underscore the need for universities to:

- Integrate AI literacy into curricula as a core competency
- Provide structured guidance on effective AI usage
- Promote ethical awareness and critical evaluation skills
- Ensure equitable access to AI tools and digital resources

CONCLUSION

This study confirms that AI literacy plays a pivotal role in shaping the effective adoption of AI-assisted learning tools and their impact on academic performance among university students across different national contexts. The findings demonstrate that higher levels of AI literacy significantly enhance students’ ability to utilize AI tools strategically, leading to improved learning outcomes and stronger academic achievement. Moreover, AI tool adoption is identified as a key mediating factor, indicating that the benefits of AI literacy are realized primarily through meaningful and purposeful engagement with AI technologies such as ChatGPT. However, cross-national disparities highlight the influence of institutional support, digital infrastructure, and educational practices in determining the effectiveness of AI integration. These results underscore the necessity for higher education institutions to embed AI literacy within curricula, promote responsible and critical use of AI, and ensure equitable access to technological resources. Ultimately, this study emphasizes that the value of AI in education lies not in the technology itself, but in the competence and awareness of its users in leveraging it for deep and sustainable learning.

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