Indonesian Journal of Educational Development (IJED)
Volume 6, Issue 3, 2025, pp. 1145-1158
ISSN: 2722-1059 (Online); ISSN: 2722-3671 (Print)
DOI: https://doi.org/10.59672/ijed.v6i3.5421

The role of artificial intelligence utilization and digital literacy in independent learning

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Article Info

Article history:
Received September 21, 2025
Revised October 09, 2025
Accepted November 20, 2025
Available online November 24, 2025

Keywords: Digital literacy, Economic education, Independent learning, Utilization of artificial intelligence

Abstract. This study analyzes the roles of artificial intelligence utilization and digital literacy in students' independent learning in the Economics Education Department, Faculty of Economics and Business, Gorontalo State University. Using a quantitative, explanatory research design, data were collected via questionnaires distributed to 234 respondents. The respondents were selected using proportional stratified random sampling by generational group. The data were analyzed using multiple linear regression in SPSS 24. The findings indicate that the utilization of artificial intelligence and digital literacy has been proven to have a simultaneous and significant impact on students' independent learning. Digital literacy has a more dominant influence than artificial intelligence, as indicated by higher Beta coefficient values and t-statistic. The implications of this research are the importance of utilizing artificial intelligence and of strengthening digital literacy in the curriculum and learning strategies, creating a higher education ecosystem that is adaptive, innovative, and supports students as independent learners in the digital age.

Introduction

Digital technology's explosive growth has changed the educational landscape both domestically and globally. In Indonesia, the utilization of artificial intelligence in higher education is on the rise, reflecting a global trend that highlights the importance of mastering digital skills and AI literacy as essential competencies for the 21st century. These skills support independent and innovative learning (Hong & Kim, 2024; Wang et al., 2022; Wu & Zhang, 2025). This phenomenon is driven by the need for graduates who are adaptable, creative, and able to learn autonomously amid disruptive technological changes (Agaoglu et al., 2025; Chiu et al., 2023). Recent data shows that integrating artificial intelligence into learning can improve access, personalization, and the effectiveness of the learning process, while also requiring students to have adequate digital literacy to utilize technology optimally (Ng et al., 2022; Wu & Zhang, 2025; Nadifa & Zulvani, 2024).

The Indonesian government strongly supports integrating artificial intelligence technology learning and digital literacy through cutting-edge education policies, including plans for coding and AI instruction from primary school to university (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2025). This phenomenon arises from the challenges students face in developing learning independence, a crucial skill for achieving academic success in the digital age. Students continue to

encounter real obstacles in cultivating this independence, which is essential for effectively managing their goals, strategies, and evaluations throughout the learning process.

Learning independence is defined as the ability of students to manage goals, strategies, and motivation actively, as well as to reflect on and evaluate their learning process (Panadero, 2017; Zimmerman & Schunk, 2011). This concept highlights that students with learning independence can set academic goals, select strategies that suit the material, and consistently assess their learning progress. Recent research confirms that learning independence is highly correlated with academic outcomes and readiness to face learning challenges in the digital age (Haryanti et al., 2025; Rahayu Ashadi & Suhaeb, 2020). Furthermore, students with a high level of learning independence tend to have stronger intrinsic motivation, good time management skills, and the ability to evaluate the effectiveness of their learning strategies (Rahmah & Setyowibowo, 2024; Syukri, 2023). Independent learning is crucial for students to achieve academic success and to prepare for lifelong learning.

At Gorontalo State University, students in the S1 Economics Education program face challenges in managing their independent learning. As a result, these students tend to rely heavily on their lecturers' guidance and the material presented in class. This dependence hinders the development of independent learning, which is essential for navigating the evolving demands of academic and professional fields. Furthermore, some students have not yet fully utilized technology to enhance their independent learning experiences. In fact, the integration of artificial intelligence in education is seen as a solution to improve learning effectiveness, motivation, and 21st-century skills, including independent learning (Rizki & Kusumah, 2025; Yurt, 2025).

The utilization of artificial intelligence in higher education is a significant innovation that can enhance the efficiency and effectiveness of the learning process. Artificial intelligence has various applications, including chatbots, adaptive learning systems, and intelligent tutoring systems. These tools enable students to access learning materials more easily, anytime and anywhere. This technology can provide instant responses and help quickly search for academic information (Dwivedi et al., 2021; Widana & Ratnaya, 2021). Additionally, artificial intelligence can optimize students' study time efficiency by facilitating the search for scientific literature, data analysis, and even grammar checking in academic writing, allowing students to focus more on developing critical and analytical thinking skills (Popenici & Kerr, 2017).

Artificial intelligence plays a crucial role in personalizing learning to meet individual student needs. AI-based systems can analyze learning patterns, adjust materials, and provide relevant learning recommendations, creating a more adaptive and meaningful learning experience (Holmes et al., 2019; Zawacki-Richter et al., 2019). Recent research indicates that the interactivity of artificial intelligence, such as automated feedback or virtual teaching assistants, can enhance student engagement, motivate them to learn more independently, and promote learning autonomy (Chen et al., 2020; Pedersen, 2025). The utilization of artificial intelligence in learning requires students to have adequate digital literacy.

Digital literacy is generally defined as a set of skills that includes the ability to access, understand, evaluate, and use digital information effectively in various contexts (Audrin & Audrin, 2022; Julien, 2019; Reddy et al., 2020; Widana et al., 2021). In higher education, digital literacy is essential as it enables students to use information technology not only for learning but also for academic communication and collaboration. Current research shows that strong digital literacy enables students to select academic information critically, assess the credibility of sources, and apply this understanding in scientific writing and discussions (Jian et al., 2023; Salimi et al., 2025; Purnadewi

et al., 2023). Additionally, digital literacy skills serve as a foundation for self-regulated learning, supporting student independence in the learning process.

Digital literacy encompasses not only the technical use of digital devices but also social and ethical considerations. Students need to be aware of digital ethics, such as plagiarism prevention, data security, and responsible behavior when interacting in virtual spaces (Pratiwi & Aisya, 2021; Summiyani et al., 2025; Kriswinahyu & Kastuhandani, 2024). Digital literacy proficiency directly impacts students' ability to use academic applications such as Google Scholar, Mendeley, and Learning Management Systems (LMS), as well as to collaborate through digital platforms such as Zoom or Google Meet (Salsabila & Abidin, 2024). Thus, digital literacy is an essential skill that equips students to tackle the challenges of 21st-century education while enhancing academic performance.

Various previous studies have shown that although AI can enhance innovation and digital literacy, there is limited research specifically examining the direct relationship between artificial intelligence utilization, digital literacy, and students' independent learning, particularly in the context of Indonesian higher education (Wang et al., 2022; Wu & Zhang, 2025; Yim & Su, 2024). Research by Wang et al. (2022) highlights the importance of institutional capacity in providing AI resources and training, but does not delve deeply into independent learning. Meanwhile, research on Chiu et al. (2023) emphasizes the role of digital literacy and faculty support in mediating learning motivation with AI, but does not explicitly link it to independent learning.

Although various studies have addressed artificial intelligence and digital literacy in education, there are still scientific gaps that need to be bridged. Findings reviewed by Wu & Zhang (2025) highlight the effects of AI on innovation and digital literacy, but they have not comprehensively linked these two variables to students' independent learning. Research by Agaoglu et al. (2025) also confirms that digital literacy acts as a mediator in the influence of artificial intelligence on creativity, but has not specifically researched the aspect of independent learning. A study by Salido et al. (2025) emphasizes the importance of critical thinking skills in artificial intelligence-based learning but does not explicitly link them to students' digital literacy. Meanwhile, Aswan (2023) affirms a positive relationship between digital literacy and independent learning in a technological educational environment, but has not yet tested the integrative role of AI as a contributing variable. On the other hand, Sagita et al. (2025) highlight the role of artificial intelligence in enhancing self-regulation through feedback systems, but the context is limited to foreign language learning. Further research is needed to incorporate artificial intelligence, digital literacy, and independent learning into students' economics education.

The theoretical contribution of this research lies in the development of a conceptual model that integrates the Technology Acceptance Model, Diffusion of Innovations, and Self-Determination Theory to explain the mechanisms of influence of AI and digital literacy on students' learning independence (Agaoglu et al., 2025; Chiu et al., 2023; Wang et al., 2022; Wu & Zhang, 2025). This research enhances the existing literature by providing updated empirical evidence on the roles of artificial intelligence and digital literacy in self-directed learning. The practical implications of these findings are intended to guide universities, educators, and policymakers in developing strategies to integrate artificial intelligence and enhance digital literacy, ultimately promoting students' independence in learning. Additionally, the results can inform the creation of training programs, curricula, and educational policies that effectively address the challenges and opportunities presented by the digital age.

This study addresses a gap in the literature and contributes to advancing higher education science and practice in the digital era. The effective implementation of artificial intelligence and digital

literacy can facilitate the creation of an adaptive, innovative learning ecosystem that supports independent learning. The research questions that guide this study are as follows: (1) To what extent does the use of artificial intelligence affect the independent learning of economics education students? (2) To what extent does digital literacy affect the independent learning of these students? (3) Does the combination of the use of artificial intelligence and digital literacy affect their independent learning?. This study hypothesizes: (1) The use of artificial intelligence has a positive and significant influence on the independent learning of economics education students; (2) Digital literacy has a positive and significant influence on the independent learning of economics education students; and (3) the combination of the two also has a positive and significant influence on the independent learning of economics education students. The purpose of this study is to analyze these influences, both partially and simultaneously, systematically.

Method

This study employed a quantitative, explanatory approach to examine the causal relationships among Artificial Intelligence utilization, digital literacy, and independent learning among students majoring in Economics Education. The research design employed a survey, in which data were collected directly through questionnaires distributed to respondents to obtain an empirical picture of the influence of variables. The study was conducted in the Department of Economics Education, Faculty of Economics and Business, Gorontalo State University. The population in this study consisted of all active students majoring in Economics Education, and the sample was selected using proportional stratified random sampling by grade level, yielding 234 respondents deemed proportionally representative of the population.

The research procedure was carried out through several systematic stages, including: (1) preparation, namely literature review, problem identification, and formulation of the research problem, hypotheses, and purposes; (2) research instrument development (table 1), namely the creation of a Likert-scale questionnaire consisting of indicators of utilization of Artificial Intelligence, digital literacy, and independent learning; (3) instrument testing, which included validity testing using Pearson product-moment correlation and reliability testing using Cronbach's Alpha coefficient. (4) the data collection stage, which involved distributing online questionnaires to selected respondents; and (5) the classical assumption testing stage, which included normality tests, multicollinearity tests, and heteroscedasticity tests to ensure the adequacy of the regression model used.

Table 1. Variables and Indicators

No.	Variable	Indicator
1.	Utilization of Artificial Intelligence (Dwivedi et al., 2021; Holmes et al., 2019; Popenici & Kerr, 2017; Zawacki-Richter et al., 2019)	Ease of access to learning with artificial intelligence
		Personalization of learning by artificial intelligence
		Efficiency of learning time with artificial intelligence
		Interactivity of artificial intelligence in the learning process
		Support of artificial intelligence in completing academic assignments
2.	Digital Literacy (Audrin & Audrin, 2022; Julien, 2019; Reddy et al., 2020)	Ability to access digital information
		Ability to evaluate online information
		Ability to use digital academic applications

No.	Variable	Indicator
		Ability to communicate and collaborate digitally
		Ethics of digital media use
3.	Learning Independence (Panadero, 2017; Zimmerman & Schunk, 2011)	Ability to set learning goals
		Internal motivation in learning
		Management Study time
		Ability to choose learning strategies
		Reflection and self-evaluation

Data analysis was conducted using multiple linear regression in SPSS version 24. This analysis included a partial test (t-test) to examine the effect of each independent variable individually on learning independence, a simultaneous test (F-test) to examine the joint effect of AI utilization and digital literacy on learning independence, and a coefficient of determination (R^2) test to measure the contribution of the independent variables in explaining the dependent variable. The results of this analysis were interpreted to test the research hypotheses and provide an empirical overview of the role of Artificial Intelligence utilization and digital literacy in enhancing learning independence for Economics Education students in the digital era.

Results and Discussion

Normality Test

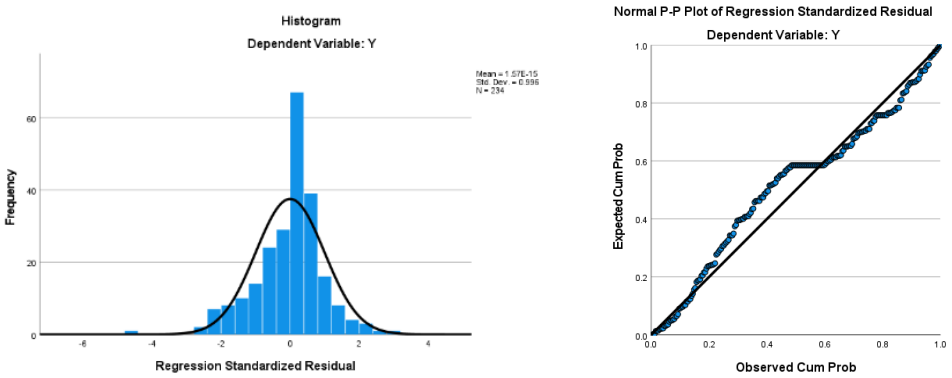

Image 1. Histogram and Normal P–P

The normality test shows that the residual data are normally distributed. This confirms the regression model is suitable for interpretation. The independent variables, artificial intelligence (AI) and digital literacy, have a linear relationship with student learning independence. Parametric tests, such as the t-test and F-test, can now be used to test the validity.

Multicollinearity Test

Table 2. Multicollinearity Test Results

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	X1	.600	1.667
	X2	.600	1.667

Tolerance is 0.600 and VIF is 1.667 for X1 and X2, both of which are below the problem threshold (Tolerance < 0.10 or VIF > 10). There is no multicollinearity, so the regression coefficients are stable and the variables' influences are reliable.

Heteroscedasticity Test

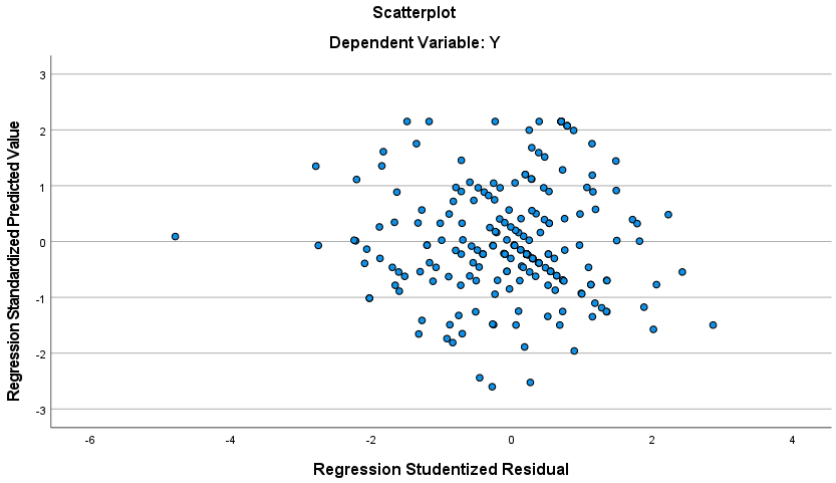

Image 2. Heteroscedasticity Test Results

The scatterplot of studentized residuals versus predicted values shows a random distribution, with no fan pattern. This suggests the residual variance is constant and that there is no heteroscedasticity. Therefore, the regression model satisfies the assumption of homoscedasticity. As a result, the relationship between the independent variables (artificial intelligence utilization and digital literacy) and learning independence can be estimated efficiently, without interference from non-constant residual variance.

Autocorrelation Test

Table 3. Durbin–Watson value

Model Summary[b]	
Model	Durbin-Watson
1	1.929

The Durbin–Watson value of 1.929, near the ideal range (1.5–2.5), indicates no residual autocorrelation. Thus, the assumption of error independence is met, and the coefficient estimates, as well as the t- and F-tests, are reliable.

Partial Test (t-test)

Table 4. Partial Test Results

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	5.567	2.081		2.676	.008
	X1	.274	.058	.271	4.743	.000
	X2	.569	.060	.540	9.457	.000

a. Dependent Variable: Y

hypothesis 1: The use of artificial intelligence has a positive and significant impact on the learning independence of students in economic education.
The analysis results show that the variable use of artificial intelligence has a regression coefficient of 0.274, a t-value of 4.743, and a significance level of 0.000 (< 0.05). This means that AI use has a positive, significant impact on students' independent learning. In other words, every increase in the use of artificial intelligence will increase students' independent learning by 0.274 units, assuming other variables remain constant. The standardized Beta value of 0.271 indicates that AI contributes 27.1% to independent learning. This finding confirms that the use of artificial intelligence can be an important driver of students' ability to learn independently.

The use of Artificial Intelligence in higher education has become one of the key drivers in shaping students' ability to learn independently. Artificial intelligence provides a variety of tools and platforms that enable personalized learning, automated feedback, and access to a vast and adaptive range of learning resources. With the advent of artificial intelligence, students can set their own pace, choose materials based on their needs, and develop more effective learning strategies, thus increasing their autonomy and confidence in the learning process (Chen et al., 2020).

Artificial intelligence also plays a role in increasing students' self-efficacy and motivation. Studies show that using artificial intelligence in higher education settings can strengthen students' belief in their own abilities, foster creativity, and improve academic performance. Artificial intelligence helps students become more confident in completing tasks independently while also providing the support needed to overcome learning challenges (Shahzad et al., 2024; Wang et al., 2022).

While artificial intelligence offers benefits, it also poses challenges, such as the risk of becoming overly reliant on technology and the potential to diminish critical thinking skills if not complemented by effective learning strategies. The research highlights the importance of balanced integration of artificial intelligence, which supports rather than replaces students' independent learning processes. This approach ensures that students continue to develop independence, creativity, and problem-solving skills (Çela et al., 2024; Darvishi et al., 2023; Zhang & Xu, 2024).

Artificial intelligence can play a crucial role in enhancing students' independence in learning if it is used to promote autonomy, motivation, and self-directed learning skills. Higher education institutions should create policies and practices that support the thoughtful use of artificial intelligence, ensuring that its advantages are fully realized without compromising students' abilities to learn independently.

hypothesis 2: Digital literacy has a positive and significant impact on the learning independence of students in economic education.
The analysis results in Table 3 show that variable digital literacy has a regression coefficient of 0.569, a t-value of 9.457, and a significance level of 0.000 (< 0.05). These results indicate that digital literacy has a positive and significant impact on students' independent learning. This means that an increase in digital literacy will have a greater influence on independent learning, specifically by 0.569 units for every one-unit increase in the digital literacy variable. The standardized Beta value of 0.540 indicates that digital literacy has a stronger relative contribution than AI use. Thus, students' ability to access, understand, and manage digital information has proven to be a key factor in supporting independent learning.

This study found that digital literacy plays a more dominant role than the use of artificial intelligence in increasing learning independence. It proved that the two variables work synergistically, a finding that fills a gap in previous research. Digital literacy has been shown to have a positive, significant impact on students' independent learning across various levels of higher education. Students with

strong digital literacy can effectively use information technology to search for, manage, and evaluate the information needed for learning. This ability encourages students to be more independent in determining their learning strategies, managing their time, and completing tasks without relying too heavily on the help of lecturers or others (Fauzi et al., 2025; Goutama et al., 2023; Nurwasiah et al., 2022; Putra & Budiningsih, 2023; Tyas & Sukartono, 2024).

Research shows that implementing digital literacy in a campus environment can increase students' motivation, sense of responsibility, initiative, and self-confidence in learning. Students who are accustomed to using digital learning resources tend to be more active in seeking materials, developing understanding, and daring to make decisions in the learning process. This aligns with the finding that digital literacy not only improves access to information but also strengthens attitudes and behaviors related to self-directed learning (Fauzi et al., 2025; Gani et al., 2025; Nurwasiah et al., 2022; Tyas & Sukartono, 2024).

Additionally, digital literacy plays a crucial role in equipping students with 21st-century skills such as critical thinking, problem-solving, and online collaboration. Students with high digital literacy are better prepared to face the challenges of learning in the digital age, including distance learning and the use of online platforms. This research also found that digital literacy can improve learning outcomes, both directly and by increasing learning independence (Gani et al., 2025; Goutama et al., 2023; Putra & Budiningsih, 2023; Salimi et al., 2025; Setyaedhi & Pramana, 2025).

Simultaneous Test (F-Test)

Table 5. Results of the Simultaneous Test (F-Test)

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2934.794	2	1467.397	140.607	.000[b]
	Residual	2410.745	231	10.436		
	Total	5345.538	233			

a. Dependent Variable: Y
b. Predictors: (Constant), X2, X1

Hypothesis 3: The use of artificial intelligence and digital literacy has a positive and significant influence on the learning independence of students in economic education.
The calculated F-value of 140.607 indicates that the regression model built has high predictive power. This figure is obtained by comparing the variation explained by the model with the unexplained variation. The larger the calculated F value, the greater the proportion of the dependent variable (Y) variation that can be explained simultaneously by the independent variables (X1 and X2). Thus, the F value indicates that the regression model is appropriate and has a strong ability to explain the relationship between the utilization of artificial intelligence and digital literacy and students' independent learning.

Moreover, the significance value (Sig.) of 0.000, which is less than the critical limit of 0.05, indicates that this regression model is statistically significant. In other words, the simultaneous use of AI and digital literacy has been shown to influence students' learning independence significantly. These findings confirm that integrating these two variables not only contributes theoretically but also empirically enhances students' self-directed learning capacity.

These findings indicate that the two variables do not operate in isolation but collaborate to shape students' ability to learn independently. The simultaneous use of artificial intelligence and digital literacy has been shown to enhance students' learning independence significantly. Integrating these

two aspects into the higher education process encourages students to be more independent in managing their learning, accessing information, and developing competencies relevant to the digital era. Research shows that AI not only enhances students' technical abilities but also strengthens digital literacy, which is an important foundation for self-directed learning (Joseph et al., 2024; Olea et al., 2025; Wang et al., 2022; Wu & Zhang, 2025; Xiao et al., 2024).

The connection between artificial intelligence and digital literacy is also synergistic. Research has found that strong digital literacy enhances the positive impact of AI use on learning independence. Students with high digital literacy are better able to optimize AI use to support their learning, such as in problem-solving, critical thinking, and innovation (Olea et al., 2025; Wu & Zhang, 2025). Conversely, effective AI use can also enhance students' digital literacy through intensive interaction with technology (Wang et al., 2022; Wu & Zhang, 2025).

The simultaneous impact of these two variables not only increases learning independence but also boosts academic achievement, creativity, and students' preparedness for the challenges of the digital world of work. Recent studies confirm that higher education institutions need to integrate AI training and digital literacy into the curriculum and provide adequate infrastructure support to realize the benefits optimally (Joseph et al., 2024; Wang et al., 2022; Xiao et al., 2024).

The contribution of this research becomes increasingly relevant considering the Indonesian government's policy of promoting digital-based education transformation and strengthening digital literacy as a core competency for students (Kementerian Pendidikan dan Kebudayaan Indonesia, 2025). The implementation of AI in learning and the improvement of digital literacy are part of the national strategy to prepare the younger generation to face global challenges that require independent and adaptive learning in response to changes in information technology. Therefore, the results of this study not only provide an empirical overview of the relationship between these variables but also support the evolving direction of national education policy.

All in all, empirical evidence confirms that the simultaneous utilization of AI and digital literacy is an effective strategy for enhancing students' learning independence. This serves as an important foundation for developing higher education policies that are responsive to technological developments and the learning needs of the 21st century (Joseph et al., 2024; Olea et al., 2025; Wang et al., 2022; Wu & Zhang, 2025; Xiao et al., 2024).

Coefficient of Determination (R^2) Test

Table 6. Results of the Coefficient of Determination Test

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.741[a]	.549	.545	3.230

The coefficient of determination is a key metric in regression analysis, providing insight into how effectively the model accounts for variation in the dependent variable given the independent variables. A coefficient of determination value of 0.549 or 54.9% indicates that variables X1 (Utilization of Artificial Intelligence) and X2 (Digital Literacy) simultaneously explain 54.9% of the variation in changes in variable Y (Learning Independence). This means that more than half of the changes or variations in students' learning independence can be predicted or explained by these two variables in this research model.

Although the contributions of artificial intelligence and digital literacy are quite significant, there is still 45.1% variation in learning independence influenced by factors other than those included in the research model. These factors can include motivation, emotional intelligence, self-efficacy, peers, or other external variables not included in the study. This finding is consistent with previous research in the field of education, where the value of the coefficient of determination in similar models indicates that the main variables do indeed have a significant influence, but there is still a contribution from other variables that need further exploration (Marthadiningrum & Widayati, 2022; Siska et al., 2022). The results indicate that while the use of AI and digital literacy are critical factors, other variables may still significantly influence students' independent learning. Therefore, the outcomes of this study support the argument that digital transformation in education is not solely a technical endeavor; it also has important implications for enhancing students' capacity for independent learning.

Conclusion

The use of Artificial Intelligence and digital literacy has a positive, significant impact on the independent learning of students majoring in economics education at Gorontalo State University. Both variables partially contribute significantly, with digital literacy having a more dominant influence than the use of artificial intelligence. Meanwhile, the use of artificial intelligence encourages students to be more independent in managing their learning. Simultaneously, the use of artificial intelligence and digital literacy plays an important role in creating an adaptive, innovative learning ecosystem that enables independent learning in the digital age. This result answers all research questions and demonstrates that the research objectives have been achieved. It provides empirical evidence on the significance of using artificial intelligence and digital literacy in students' independent learning in economics education.

For future research, it is hoped that other variables, such as learning motivation, self-efficacy, and academic environment support, will be included to provide a more comprehensive picture of the factors influencing students' learning independence in the digital transformation era.

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