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Research Article

The Influence of Digital Literacy, Self-Regulation, and Independent Learning on the Understanding of Technological, Pedagogical, and Content Knowledge (TPACK) Among Economics Education Students as Prospective Economics Teachers

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Abstract: This study aims to analyze the role of digital literacy, self-regulation, and independent learning in enhancing the understanding of Technological, Pedagogical, and Content Knowledge (TPACK) among Economics Education students. The research employed a quantitative approach with a survey design. Data were collected using a four-point Likert-scale questionnaire administered to 237 students selected from a total population of 588 Economics Education students from the 2020–2023 cohorts. The research instruments were tested for validity and reliability, while data analysis was conducted using classical assumption tests and multiple linear regression. The findings reveal that digital literacy, self-regulation, and independent learning each have a positive and significant effect on students' understanding of TPACK (p-value < 0.05). Simultaneously, these three variables exert a significant combined influence, with a coefficient of determination (R^2) of 0.723, indicating that 72.3% of the variance in TPACK understanding can be explained by these independent variables. These findings emphasize that digital literacy is the most dominant factor supporting students' readiness as prospective economics teachers who can adapt to advancements in educational technology.

Keywords: Content Knowledge (TPACK); Digital Literacy; Independent Learning; Self-Regulation; Technological Pedagogical.

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1. Introduction

Technological advances in the 21st century have driven a shift in educational paradigms from teacher-centered approaches to student-centered learning (Mawarni et al., 2025). In this context, integrating technology into the learning process is no longer optional but a necessity, particularly in the era of the Industrial Revolution 4.0. One key framework that facilitates such integration is Technological Pedagogical and Content Knowledge (TPACK), which emphasizes the ability of prospective teachers to effectively combine technological, pedagogical, and content knowledge in the teaching process (Mishra & Koehler, 2005; Hidayati & Choiriyah, 2024). However, students in the Economics Education program at Yogyakarta State University (UNY) continue to face significant challenges in mastering TPACK. This is reflected in the declining GPA trend over the past three years, indicating a gap in their ability to integrate technology with pedagogy and content.

Several internal factors are believed to play pivotal roles in enhancing TPACK understanding, including: digital literacy, which allows students to effectively access, evaluate, and utilize digital learning resources (Debitama et al., 2024); self-regulation, which enables students to plan, monitor, and adjust their learning strategies for optimal results (Ramadhani et al., 2022); and independent learning, which promotes proactive engagement in leveraging

technology and learning resources to achieve academic objectives (Schunk & Zimmerman, 2022; Putrie, 2021).

Although previous studies have highlighted the importance of mastering TPACK for teacher readiness (Zahwa & Pahlevi, 2024), there remains a lack of research focusing specifically on the influence of digital literacy, self-regulation, and independent learning on TPACK understanding among Economics Education students at UNY. This indicates the need for more targeted studies, making the present research highly relevant to understanding the factors that shape prospective teachers' competence in integrating technology, pedagogy, and content in today's digital education era.

2. Literature Review

Grand Theory

Communication Theory (Computer-Mediated Communication Theory)

Computer-Mediated Communication (CMC) explains how communication through digital media influences interaction and learning (Walther & Burgoon, 1992). In the field of education, CMC facilitates online collaboration, discussions, and the creation of virtual learning communities (Hope-Hume, 2002). In this environment, students actively serve as knowledge creators, while teachers act as facilitators. CMC fosters flexibility, independence, and communication skills, though it simultaneously demands strong self-regulation and effective time management for optimal learning outcomes.

Motivation Theory (Self-Determination Theory-SDT)

Self-Determination Theory (Deci & Ryan, 1985) emphasizes that intrinsic motivation emerges when three basic psychological needs are fulfilled: autonomy, competence, and relatedness. In an educational context, self-regulation and independent learning reflect the autonomy and competence of students. Learners with high intrinsic motivation tend to engage more actively in developing their understanding of Technological, Pedagogical, and Content Knowledge (TPACK) and are better equipped to manage technology-based learning independently and effectively.

Self-Efficacy Theory

The Self-Efficacy Theory, developed by Bandura (1977), highlights the individual's belief in their ability to perform actions required to achieve desired outcomes. Within technology-based learning contexts, self-efficacy plays a pivotal role in determining students' success in integrating technology, including their mastery of TPACK. Students with high self-efficacy exhibit greater confidence in using digital tools, actively engage in collaboration, and demonstrate strong self-regulation in learning. Conversely, those with low self-efficacy often experience heightened anxiety and avoidance behaviors, which hinder their ability to maximize learning outcomes.

Self-Determination Theory (SDT)

Self-Determination Theory (Deci & Ryan, 1985) highlights that intrinsic motivation emerges when three psychological needs are met: autonomy, competence, and relatedness. In education, self-regulation and independent learning reflect autonomy and competence. Intrinsically motivated students are more proactive in developing TPACK understanding and are better at managing technology-based learning independently.

Self-Efficacy Theory

Bandura's (1977) Self-Efficacy Theory emphasizes an individual's belief in their ability to execute actions to achieve desired outcomes. In technology-based learning, self-efficacy determines students' success in integrating technology, including mastering TPACK. High self-efficacy fosters confidence in using digital tools, encourages collaboration, and enhances self-regulated learning, whereas low self-efficacy often results in anxiety and avoidance.

Understanding Technological Pedagogical Content Knowledge (TPACK)

TPACK

Technological Pedagogical Content Knowledge (TPACK) is a framework for integrating technology into the teaching and learning process, encompassing technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) (Hardanti, 2024). This concept originated from Pedagogical Content Knowledge (PCK) introduced by Shulman (1986) and was later expanded by Mishra and Koehler (2009) and Hidayati and Choiriyah (2024) with the addition of the technological dimension. The interaction among these components gives rise to PCK, TCK, TPK, and the fully integrated TPACK model. TPACK serves as a comprehensive framework that enables teachers to design innovative, effective, and relevant instruction that meets the challenges of 21st-century education.

Digital Literacy Competence

Literacy was initially defined as the ability to read and write (Sulzby, 1986; Astuti, 2007), but its scope has since expanded to include digital, financial, scientific, cultural, and civic literacies (Trilling & Fadel, 2009; Muhimmatin & Prasetiyo, 2024). In the digital era, literacy refers to the ability to access, process, and critically analyze information through various technological platforms (Debitama et al., 2024; Yulia & Eliza, 2021). Debitama et al. (2024) highlight four key indicators of digital literacy: information search, hypertext navigation, content evaluation, and information reconstruction. These competencies are essential for supporting learning processes in the context of 21st-century education.

Self-Regulation

Self-regulation is a metacognitive process that involves planning, monitoring, and self-evaluation during learning activities, including strategy management and time management to achieve academic goals (Ramadhani et al., 2022). Zimmerman and Schunk, as cited in Putrie (2021), define self-regulation as the ability of individuals to systematically direct their thoughts, emotions, and actions toward desired outcomes. Consequently, self-regulation plays a critical role in academic success, as it determines the extent to which students can control and guide their own learning processes effectively.

Independent Learning

Independent learning is essential for students to exercise self-control, foster motivation, and manage academic activities without relying excessively on others (Bukit et al., 2022). This attitude helps students develop their potential, expand knowledge, and nurture creativity. According to Rahayu and Aini (2021), independent learning is shaped by thoughts, emotions, strategies, and attitudes aimed at achieving learning goals. It involves initiative, self-management, evaluation of results, and optimal utilization of learning resources. Therefore, independent learning does not imply studying in isolation but rather reflects a proactive approach to learning that minimizes dependence on external assistance.

3. Materials and Method

This study employed a quantitative approach using an explanatory survey method with a correlational design to examine the influence of digital literacy, self-regulation, and independent learning on the understanding of TPACK among Economics Education students. The research was conducted at Yogyakarta State University over a period of four months. The study population consisted of 588 undergraduate Economics Education students from the 2020–2023 cohorts. A total of 237 students were selected as the research sample using purposive sampling and the Slovin formula with a 5% margin of error to ensure representativeness.

4. Results and Discussion

Classical Assumption Tests

Normality Test

The normality test aimed to determine whether the residual data in the regression model were normally distributed, a prerequisite for multiple linear regression analysis. Using the Kolmogorov-Smirnov (K-S) test, data are considered normally distributed if the Asymp. Sig. (2-tailed) value exceeds 0.05.

Table 1. Results of the Kolmogorov-Smirnov Normality Test.

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		237
Normal Parameters[a,b]	Mean	0,0000000
	Std. Deviation	3,19771076
Most Extreme Differences	Absolute	0,057
	Positive	0,055
	Negative	-0,057
Test Statistic		0,057
Asymp. Sig. (2-tailed)		,059[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Source: SPSS Output, Processed Data (2025)

The results showed an Asymp. Sig. value of 0.059, greater than 0.05, indicating that the residual data are normally distributed and meet the classical assumption for regression analysis.

Multicollinearity Test

Multicollinearity testing was conducted to identify high correlations between independent variables in the regression model. Multicollinearity can interfere with the accuracy of coefficient estimates, resulting in biased analysis results. The criteria used were a Tolerance value > 0.10 and a VIF < 10, indicating that the model was free from multicollinearity issues.

Table 2. Multicollinearity Test Results.

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	(Constant)		
	X1	0,492	2,033
	X2	0,489	2,046
	X3	0,368	2,718

a. Dependent Variable: Y

Source: SPSS Output, Processed Data (2025)

Based on the results of the multicollinearity test in the table above, all variables have a Tolerance value > 0.10 and VIF < 10, namely Tolerance 0.368–0.492 and VIF 2.033–2.718. This indicates that there are no symptoms of multicollinearity, so the regression model is suitable for use.

Heteroscedasticity Test

The heteroscedasticity test aimed to identify whether there were inconsistencies in the variance of the residuals across predicted values. A model is considered free from heteroscedasticity if the significance (Sig.) value is greater than 0.05.

Table 3. Heteroscedasticity Test Results (Glejser Test).

Coefficients[a]					
		Unstandardized Coefficients			
Model		B	Std. Error	t	Sig.
1	(Constant)	1,619E-15	2,794	0,000	1,000
	X1	0,000	0,071	0,000	1,000
	X2	0,000	0,081	0,000	1,000
	X3	0,000	0,039	0,000	1,000

a. Dependent Variable: Unstandardized Residual

Source: SPSS Output, Processed Data (2025)

Based on the results of the heteroscedasticity test (Glejser test) in the table above, the significance value (Sig.) for variables X1, X2, and X3 is 1.000, which is greater than 0.05. Thus, there is no significant effect of the independent variables on the residuals, so it can be concluded that the model is free from heteroscedasticity and meets the classical assumptions for use in further regression analysis.

Multiple Linear Regression Analysis Results

Regression Equation

Multiple linear regression analysis was used to measure the effect of digital literacy (X1), self-regulation (X2), and learning independence (X3) on TPACK understanding (Y), with the regression equation constructed from the Unstandardized Coefficients (B).

Table 4. Multiple Linear Regression Results.

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	8,007	2,794		2,866	,005
X1	,332	,071	,231	4,693	,000
X2	,407	,081	,247	5,011	,000
X3	,324	,039	,473	8,314	,000

a. Dependent Variable: Y

Source: SPSS Output, Processed Data (2025)

Based on the results of the multiple linear regression equation in the table above, the following result is obtained: Y = 8.007 + 0.332X1 + 0.407X2 + 0.324X3. Interpretation: the constant 8.007 indicates the base value of TPACK; each increase in digital literacy (X1), self-

regulation (X2), and learning independence (X3) increases TPACK understanding by 0.332, 0.407, and 0.324 points, respectively.

Partial Significance Test (t-test)

The partial t-test is used to examine the effect of each independent variable (X1, X2, X3) on TPACK understanding (Y). If the Sig. value is < 0.05, then the variable has a significant partial effect.

Table 5. Partial Significance Test Results (t-test).

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	T	Sig.
1 (Constant)	8,007	2,794		2,866	,005
X1	,332	,071	,231	4,693	,000
X2	,407	,081	,247	5,011	,000
X3	,324	,039	,473	8,314	,000

a. Dependent Variable: Y

Source: SPSS Output, Processed Data (2025)

Based on the results of the partial significance test (t-test) in the table above, the partial t-test results show that digital literacy (X1), self-regulation (X2), and learning independence (X3) each have a significance value of 0.000 (< 0.05). The t-values obtained for X1 are 4.693, for X2 are 5.011, and for X3 are 8.314. These results indicate that the three independent variables have a positive and significant effect on TPACK understanding. In other words, the higher the digital literacy, self-regulation, and learning independence of students, the better their understanding of TPACK. In addition, the learning independence variable (X3) shows the strongest influence compared to the other two variables.

Simultaneous Significance Test (F-test)

The F-test is used to test whether digital literacy (X1), self-regulation (X2), and learning independence (X3) simultaneously have a significant effect on TPACK understanding (Y), with a criterion of Sig. < 0.05.

Table 6. Simultaneous Significance Test Results (F Test).

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	6289,306	3	2096,435	202,417	,000[b]
Residual	2413,184	233	10,357		
Total	8702,489	236			

a. Dependent Variable: Y

b. Predictors: (Constant), X3, X1, X2

Source: SPSS Output, Processed Data (2025)

Based on the results of the simultaneous significance test (F test) in the table above, the calculated F value = 202.417 with Sig. = 0.000 < 0.05, so it can be concluded that digital literacy, self-regulation, and learning independence simultaneously have a significant effect on TPACK understanding.

Coefficient of Determination (R^2)

The coefficient of determination (R^2) is used to determine how much the independent variables can explain the variation that occurs in the dependent variable. The higher the R^2 value, the greater the proportion of the independent variables' influence on the dependent variable, so that the regression model is considered better at explaining the relationship between variables.

Table 7. Coefficient of Determination (R^2) Results.

Model Summary					
Model	R	R Square	Adjusted R Square		Std. Error of the Estimate
1	,850[a]	,723	,719		3,21823

a. Predictors: (Constant), X3, X1, X2

Source: SPSS Output, Processed Data (2025)

Based on Table 7, the R Square value of 0.723 indicates that 72.3% of the variation in TPACK understanding can be explained by digital literacy, self-regulation, and learning independence, while 27.7% is influenced by other factors outside the model. The Adjusted R Square value of 0.719 reinforces the stability of the model, and the Standard Error of 3.21823 indicates a relatively small prediction error.

The Effect of Digital Literacy on TPACK Understanding

The t-test shows that digital literacy has a significant effect on students' TPACK understanding (Sig. = 0.000). Students with high digital literacy are better able to integrate technology, pedagogy, and content, in line with CMC theory. This finding is also supported by Debitama et al.'s (2024) research, which confirms the relationship between digital literacy and learning independence as the basis for mastering TPACK.

The Effect of Self-Regulation on TPACK Understanding

The t-test shows that self-regulation has a significant effect on students' understanding of TPACK (Sig. = 0.000). Students with high self-regulation are able to plan, monitor, and evaluate the learning process effectively, including in technology-based learning. In line with Self-Determination Theory (Deci & Ryan, 1985), self-regulation encourages intrinsic motivation that strengthens TPACK mastery. This finding is supported by Putrie (2021), who states that self-regulation contributes to learning achievement and understanding of complex concepts.

The Effect of Independent Learning on TPACK Understanding

The t-test shows that independent learning has a significant effect on students' TPACK understanding (coefficient = 0.324; Sig. = 0.000). Independent students are able to plan, organize, and evaluate their learning optimally, making them better prepared to integrate technology into learning. This is in line with Self-Efficacy Theory (Bandura, 1977), which emphasizes self-confidence as an important factor in learning success. Research by Damayanti & Afriansyah (2024) and Loka et al. (2024) also supports that learning independence is positively related to learning outcomes, especially in technology-based learning.

The Simultaneous Influence of Digital Literacy, Self-Regulation, and Learning Independence on TPACK Understanding

Simultaneously, digital literacy, self-regulation, and learning independence have a significant effect on students' understanding of TPACK, as evidenced by the F test = 202.417 (Sig. = 0.000) and $R^2 = 0.723$, meaning that 72.3% of TPACK variation is explained by the three variables. This finding supports Putri & Surjanti (2024), who emphasize the importance of personal aspects, such as self-efficacy and pedagogical knowledge, in TPACK mastery. Other studies (Zahwa & Pahlevi, 2024; Fahira & Putra, 2024) show that students' mastery of TPACK is still moderate, so technology-based interventions, digital literacy, self-regulation, and independent learning need to be improved. This study confirms that the three variables have a positive and significant influence, both partially and simultaneously, and recommends learning strategies that support the development of digital literacy, self-regulation, and independent learning through the integration of technology, projects, problem-based learning, self-assessment, and self-reflection.

5. Conclusion

Digital literacy has a positive and significant effect on the TPACK understanding of Economics Education students at Yogyakarta State University. The higher the level of digital literacy, the better the students' ability to integrate technology, pedagogy, and content effectively. Self-regulation has a positive and significant influence on TPACK understanding. Students who can independently manage and evaluate their learning processes tend to have a deeper comprehension of TPACK and demonstrate greater competence in its practical application.Independent learning has a positive and significant impact on TPACK understanding. Students with a strong sense of learning autonomy exhibit a greater ability to integrate technology, pedagogy, and content in their learning and teaching processes. Digital literacy, self-regulation, and independent learning collectively contribute 72.3% to the variation in students' TPACK understanding, highlighting the crucial role of these internal factors. The remaining 27.7% is influenced by other variables not examined in this study.

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