Vol. 9, No.1, 2026, pp. 298-306
DOI: https://doi.org/10.32698/02276

Contents lists available at Journal Global Econedu

Journal of Educational and Learning Studies
ISSN: 2655-2760 (Print) ISSN: 2655-2779 (Electronic)

Journal homepage: http://jurnal.globaleconedu.org/index.php/jels

Deep learning implementation in mentawai vocational schools: pedagogical readiness, educational technology utilization, and institutional support

Heri Noviko, Muhammad Adri[*)], M. Giatman, Hendra Hidayat
Universitas Negeri Padang, Padang, Indonesia

Article Info

Article history:

Received Apr 13th, 2026
Revised May 15th, 2026
Accepted Jun 30th, 2026

Keywords:

Deep learning implementation, pedagogical readiness, Educational technology utilization, Institutional support

ABSTRACT

This study examined the contributions of teachers' pedagogical readiness and educational technology utilization to deep learning implementation through institutional support in public vocational schools in the Mentawai Islands Regency. An explanatory cross-sectional survey targeted all 70 teachers, with 65 complete responses analyzed using PLS-SEM. Pedagogical readiness contributed significantly to deep learning implementation ($\beta = 0.330$, $p = 0.034$) and institutional support ($\beta = 0.456$, $p = 0.007$). Educational technology utilization did not contribute significantly to deep learning implementation or institutional support. Institutional support also showed no significant direct contribution to deep learning implementation and did not mediate the relationships involving pedagogical readiness or educational technology utilization. These findings identify pedagogical readiness as the most consistent factor in the model. Strengthening teachers' pedagogical competence, aligning technology use with instructional objectives, and translating institutional support into concrete instructional assistance are important for improving deep learning practices in geographically remote vocational schools.

Corresponding Author:

Muhammad Adri,
Universitas Negeri Padang
Email: mhd.adri@unp.ac.id

Introduction

The rapid development of twenty-first-century education has shifted learning from knowledge acquisition toward developing critical thinking, creativity, collaboration, communication, and problem-solving skills. In response, deep learning has emerged as an instructional approach that promotes meaningful understanding, active engagement, and authentic knowledge application rather than rote memorization (Andriyani et al., 2025; Utomo et al., 2025; Zary & Zary, 2025). In this study, deep learning refers to a pedagogical approach rather than artificial intelligence or machine learning. In Indonesia, this approach has been reinforced through recent Indonesian curriculum policy and the 2026 Process Standards, which emphasize meaningful, mindful, and joyful learning across all educational levels (Halomoan et al., 2026; Istiningsih, 2022; Pan & Jiang, 2025). Consequently, deep learning has become a strategic priority for improving instructional quality, particularly in vocational education.

Implementing deep learning in vocational schools requires teachers to integrate pedagogical competence with authentic, industry-oriented learning experiences. Previous studies consistently identify teachers' pedagogical competence as a key factor influencing instructional quality and student learning outcomes (Inderanata & Sukardi, 2023; Wahyuningsih et al., 2025). At the same time, educational technology has become increasingly important in supporting student-centered learning. According to the Technological Pedagogical Content Knowledge (TPACK) framework, however, technology contributes effectively only when integrated with pedagogical and content knowledge (Mishra & Koehler, 2006; Fitrah et al., 2025; Waloyo et al., 2026). Recent studies further confirm that technology integration improves instructional innovation when supported by strong pedagogical competence.

Beyond individual teacher competence, institutional support also plays an essential role in facilitating deep learning implementation. Leadership commitment, professional development, collaborative culture, and adequate learning resources create conditions that encourage instructional innovation (Pasi & Dhamak, 2026; Yulin & Danso, 2025). Likewise, Purnama et al. (2025) emphasize that transforming Technical and Vocational Education and Training (TVET) requires an institutional ecosystem that supports continuous teacher development and digital transformation. Nevertheless, vocational schools in geographically remote and archipelagic regions often experience limited infrastructure, restricted access to professional development, and unequal digital resources, potentially constraining the implementation of deep learning.

This study is conceptually grounded in Social Cognitive Theory, which explains professional behavior through reciprocal interactions among personal factors, environmental conditions, and behavior (Bandura, 1986). In the present model, teachers' pedagogical readiness represents a personal factor because it reflects teachers' professional capacity to plan, implement, assess, and reflect on instruction. Institutional support represents an environmental factor because school policies, leadership, professional development, supervision, infrastructure, and technical assistance may support or constrain teachers' instructional practices. Meanwhile, educational technology utilization and deep learning implementation represent forms of professional teaching behavior expressed through teachers' classroom and vocational learning practices. This theoretical perspective provides an integrated foundation for examining how teachers' personal capacities and perceived institutional conditions are associated with the implementation of deep learning in vocational schools.

The urgency of this study is further supported by preliminary empirical evidence from public vocational schools in the Mentawai Islands Regency. A preliminary survey involving 35 vocational school teachers showed that 51.43% perceived administrative workload as limiting the time available to design deep learning activities. In addition, 68.57% reported that information and communication technology had not yet become a primary means of learning interaction, while 85.71% perceived technical support and internet access as inadequate for daily digital learning. Furthermore, 45.71% indicated that teacher training remained too theoretical for productive vocational subjects, and 74.29% observed that students tended to focus more on grades than on understanding the relevance and practical benefits of learning materials. These conditions indicate that deep learning implementation in the Mentawai Islands is shaped by interconnected pedagogical, technological, institutional, and learner-related challenges.

Although previous studies have examined teachers' pedagogical competence, technology integration, and institutional support, these variables have generally been investigated separately (Isnaeni et al., 2025; Riani & Sujarwati, 2025). Empirical evidence that simultaneously examines these factors in explaining deep learning implementation, particularly using PLS-SEM, remains limited. Furthermore, most existing studies have focused on urban or general education settings, whereas research involving vocational schools in remote island regions is still scarce (Mpuangnan, 2024; Subiyantoro et al., 2024).

Another important gap concerns the limited evidence regarding the mediating role of institutional support in the relationship between teachers' pedagogical readiness, educational technology utilization, and deep learning implementation. While institutional support has been shown to enhance teacher performance and technology adoption (Marín-Rodríguez et al., 2025; Ponnupillai et al., 2025), its role in facilitating deep learning remains underexplored. Similarly, recent Indonesian studies have mainly assessed teachers' readiness for deep learning or technology integration independently (Grustan et al., 2026; Suherman et al., 2025), leaving the interaction among these constructs insufficiently understood.

This study addresses these gaps by proposing an integrated PLS-SEM model that examines the relationships among teachers' pedagogical readiness, educational technology utilization, institutional support, and deep learning implementation in public vocational schools in the Mentawai Islands Regency. The novelty of this research lies in integrating these variables within a single structural model, positioning institutional support as a mediating construct, and providing empirical evidence from vocational schools in a remote archipelagic context, which has received limited scholarly attention. Accordingly, this study aims to analyze the direct effects of teachers' pedagogical readiness and educational technology utilization on deep learning implementation, examine their influence on institutional support, and evaluate the mediating role of institutional support in supporting deep learning implementation. The findings are expected to contribute to the literature on vocational education and provide evidence-based recommendations for strengthening teacher capacity and improving instructional quality in geographically disadvantaged regions.

Based on the proposed theoretical framework, seven hypotheses were formulated: pedagogical readiness contributes positively to deep learning implementation (H1); educational technology utilization contributes positively to deep learning implementation (H2); pedagogical readiness contributes positively to institutional support (H3); educational technology utilization contributes positively to institutional support (H4); institutional support contributes positively to deep learning implementation (H5); institutional support mediates the relationship between pedagogical readiness and deep learning implementation (H6); and institutional support mediates the relationship between educational technology utilization and deep learning implementation (H7).

Method

This study employed a quantitative approach using an explanatory cross-sectional survey design to examine the relationships among teachers' pedagogical readiness, educational technology utilization, institutional support, and deep learning implementation in public vocational schools. The explanatory design was selected because the study aimed to investigate both the direct and indirect (mediating) effects among the proposed latent constructs within a single conceptual model. Data were collected once during the study period using a structured self-administered questionnaire, enabling the assessment of respondents' perceptions at a specific point in time. Because the data were obtained from a single measurement occasion, the findings were interpreted as predictive and associative relationships rather than causal effects. The study was conducted in three public vocational schools (SMKN 1, SMKN 2, and SMKN 3) located in the Mentawai Islands Regency, West Sumatra, Indonesia, between January and June 2026. These schools operate under the same provincial education authority and curriculum framework, providing a relatively homogeneous institutional context while representing the unique characteristics of vocational education in an archipelagic and geographically remote region.

The target population comprised all 70 active teachers employed in the three participating public vocational schools. Because the population size was relatively small and fully accessible, total sampling (census sampling) was adopted, allowing every eligible teacher to participate in the study. After data screening, 65 complete questionnaires were retained for analysis. The research instrument consisted of a structured questionnaire measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Four latent constructs were investigated: teachers' pedagogical readiness (X1), educational technology utilization (X2), institutional support (M), and deep learning implementation (Y). Teachers' pedagogical readiness, educational technology utilization, and deep learning implementation were specified as reflective constructs, whereas institutional support was modeled as a formative construct. Prior to the main survey, the instrument underwent expert validation and pilot testing to establish content validity and improve item clarity. Internal consistency and construct validity were subsequently assessed through the Partial Least Squares Structural Equation Modeling (PLS-SEM) measurement model.

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) implemented in SmartPLS. This analytical approach was selected because the proposed research model simultaneously examined multiple direct and indirect relationships, incorporated both reflective and formative measurement models, emphasized prediction-oriented analysis, and accommodated the relatively limited sample size. The analysis was conducted in several stages. First, descriptive statistics were calculated to summarize respondents' characteristics and the distribution of each research variable. Second, the measurement model was evaluated by assessing indicator reliability, internal consistency reliability (Cronbach's alpha and composite reliability), convergent validity (average variance extracted), and discriminant validity (HTMT) for reflective constructs, while formative constructs were assessed using outer weights, outer loadings, and variance inflation factor (VIF). Third, the structural model was evaluated through collinearity diagnostics, path coefficients, coefficients of determination (R^2), effect sizes (f^2), and predictive performance using PLSpredict and Q^2_predict values. Finally, the proposed hypotheses, including the mediating role of institutional support, were tested using the bootstrapping procedure with a one-tailed significance level of 5%, where relationships were considered statistically significant when t-values exceeded 1.65 and p-values were below 0.05.

Results and Discussion

This section presents the empirical findings obtained from the analysis of data collected from teachers in three public vocational schools in the Mentawai Islands Regency. The results are organized into six main components: respondent characteristics, descriptive statistics, measurement model evaluation, structural model evaluation, hypothesis testing, and a summary of the principal findings. Descriptive analysis was first used to portray the respondents and the general tendency of each construct. Subsequently, Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied to assess the validity and reliability of the measurement model, evaluate the explanatory and predictive power of the structural model, and test the proposed direct and indirect relationships. All analyses were conducted using data from 65 valid respondents.

Table 1. Demographic Characteristics of Respondents (n = 65)

Characteristic	Category	Frequency	Percentage (%)
School	SMKN 1 Mentawai Islands	21	32.31
	SMKN 2 Mentawai Islands	22	33.85
	SMKN 3 Mentawai Islands	22	33.85
Gender	Male	22	33.85
	Female	43	66.15
Age	<30 years	6	9.23
	30–39 years	44	67.69
	40–49 years	14	21.54
	≥50 years	1	1.54
Teaching Experience	<5 years	12	18.46
	5–10 years	40	61.54
	11–20 years	13	20.00
Educational Qualification	Bachelor's	63	96.92
	Master's	2	3.08
Employment Status	Civil servant	54	83.08
	Non-civil servant	11	16.92

Table 1 shows that the study involved 65 valid respondents, representing 92.86% of the target population. Respondents were almost equally distributed across the three public vocational schools, ensuring balanced institutional representation. Female teachers accounted for 66.15% of the sample, while the majority were between 30 and 39 years old (67.69%) and had 5–10 years of teaching experience (61.54%). Most participants held a bachelor's degree (96.92%) and were civil servants (83.08%), indicating that the respondents possessed relatively stable professional backgrounds and sufficient teaching experience to evaluate deep learning implementation in vocational education.

Table 2. Descriptive Statistics of Research Variables

Variable	Mean	Item SD Range	Category
Teachers' Pedagogical Readiness	4.106	0.527–0.805	High
Educational Technology Utilization	3.572	0.811–0.883	High
Institutional Support	3.434	0.770–1.019	High
Deep Learning Implementation	4.173	0.493–0.605	High

Table 2 indicates that all latent variables achieved mean scores within the high category. Deep learning implementation obtained the highest average score (M = 4.173), followed by teachers' pedagogical readiness (M = 4.106). In contrast, educational technology utilization (M = 3.572) and institutional support (M = 3.434) recorded comparatively lower means, although both remained within the high category. These findings suggest that teachers perceived themselves as pedagogically prepared and actively implementing deep learning practices; however, technological integration and institutional support had not yet reached the same level of maturity, particularly within the geographical context of the Mentawai Islands.

Table 3 demonstrates that the measurement model satisfied the recommended SEM-PLS criteria. Most reflective indicators exhibited outer loading values above 0.70, while indicators with slightly lower loadings were retained because composite reliability and AVE remained above the recommended thresholds. Cronbach's alpha values ranged from 0.921 to 0.940, composite reliability ranged from 0.937 to 0.950, and AVE values ranged from 0.633 to 0.682, confirming satisfactory internal consistency and convergent validity. Furthermore, the formative construct showed VIF values below 5.00, indicating the absence of multicollinearity, while indicators M1.3 and M2.2 contributed significantly to institutional support. Overall, the measurement model was considered valid and reliable for structural analysis.

Discriminant validity was established because all HTMT values were below the recommended threshold, indicating that the reflective constructs were empirically distinct. The convergent validity of the formative institutional support construct was further confirmed through redundancy analysis. The relationship between institutional support and its global single-item measure was strong and significant (β = 0.817, t = 12.828, $p < 0.001$), with an R^2 value of 0.668.

Table 3. Measurement Model Evaluation

Construct	Outer Loading	Cronbach's Alpha	Composite Reliability	AVE	Result
Teachers' Pedagogical Readiness	0.587–0.882	0.921	0.937	0.651	Valid & Reliable
Educational Technology Utilization	0.666–0.915	0.940	0.950	0.682	Valid & Reliable
Deep Learning Implementation	0.727–0.863	0.927	0.939	0.633	Valid & Reliable
Institutional Support (Formative)	VIF < 5; Significant outer weights for M1.3 and M2.2				Valid

Table 4. Structural Model Evaluation

Indicator	Value	Interpretation
Highest Inner VIF	1.935	No collinearity
R^2 Institutional Support	0.363	Moderate
R^2 Deep Learning Implementation	0.278	Weak–Moderate
Largest f^2	0.203	Medium
Predictive relevance	15/17 positive Q^2_predict	Predictive relevance for most indicators

Table 4 shows that the structural model fulfilled the assumptions required for hypothesis testing. All inner VIF values were below 5.00, indicating that multicollinearity was not a concern. The model explained 36.3% of the variance in institutional support and 27.8% of the variance in deep learning implementation, suggesting a moderate explanatory capability typical of educational research. The largest effect size was observed for the relationship between pedagogical readiness and institutional support (f^2 = 0.203), whereas most remaining relationships demonstrated small effects. In addition, 15 of the 17 substantive endogenous indicators produced positive Q^2_predict values. Two indicators, M3.3 and Y1.2, showed slightly negative Q^2_predict values. Therefore, the model demonstrated predictive relevance for most endogenous indicators, although its predictive performance should be interpreted cautiously.

Table 5. Hypothesis Testing

Hypothesis	Relationship	β	t	p	Decision
H1	Pedagogical Readiness to Deep Learning	0.330	1.824	0.034	Supported
H2	Technology Utilization to Deep Learning	0.228	1.618	0.053	Not Supported
H3	Pedagogical Readiness to Institutional Support	0.456	2.468	0.007	Supported
H4	Technology Utilization to Institutional Support	0.203	1.178	0.119	Not Supported
H5	Institutional Support to Deep Learning	0.037	0.191	0.424	Not Supported
H6	Pedagogical Readiness to Institutional Support to Deep Learning Implementation	0.017	0.179	0.429	Not Supported
H7	Educational Technology Utilization to Institutional Support to Deep Learning Implementation	0.007	0.114	0.454	Not Supported

Table 5 shows that only two of the seven proposed hypotheses were supported. Teachers' pedagogical readiness showed significant positive contributions to both deep learning implementation (β = 0.330, p = 0.034) and institutional support (β = 0.456, p = 0.007). In contrast, educational technology utilization did not show significant contributions to either institutional support or deep learning implementation. Institutional support was not significantly associated with deep learning implementation and did not mediate the relationships involving pedagogical readiness or educational technology utilization. These findings identify pedagogical readiness as the most consistent factor in the proposed research model.

Figure 1 illustrates the final structural model estimated using the bootstrapping procedure in PLS-SEM. The figure presents the standardized path coefficients and coefficients of determination (R^2) for the endogenous constructs. Teachers' pedagogical readiness showed significant positive contributions to both institutional support and deep learning implementation, whereas educational technology utilization and institutional support did not show significant contributions to deep learning implementation.

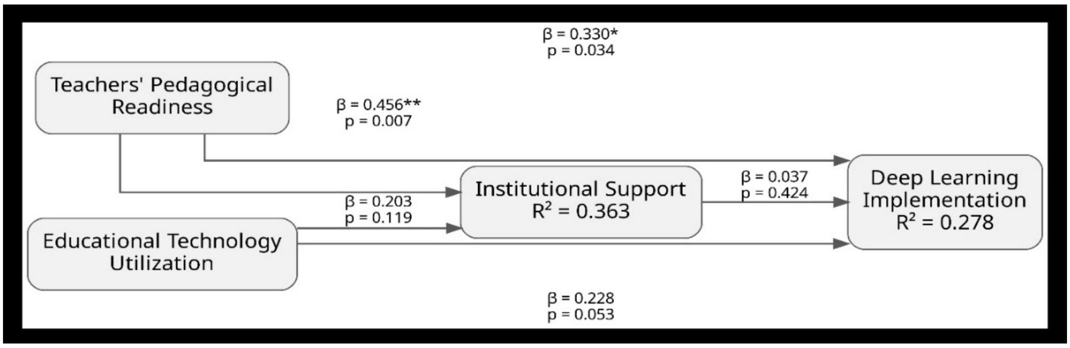

Figure 1. Final structural model with standardized path coefficients and coefficients of determination

The findings identify teachers' pedagogical readiness as the most consistent factor associated with deep learning implementation in vocational schools in the Mentawai Islands. Although all constructs were rated within the high descriptive category, only pedagogical readiness showed significant contributions to deep learning implementation and institutional support. This distinction indicates that positive teacher perceptions do not automatically produce strong structural relationships among constructs. The model explained 36.3% of the variance in institutional support and 27.8% of the variance in deep learning implementation, suggesting that additional contextual and professional factors remain relevant. These findings support Social Cognitive Theory by demonstrating the comparatively stronger role of personal factors in professional teaching behavior. They also reinforce the Pedagogical Content Knowledge framework, which positions teachers' pedagogical competence as a foundation for effective instructional practice (Shulman, 1986, 1987).

From the perspective of Social Cognitive Theory, the findings show that the personal factor represented by teachers' pedagogical readiness was more consistent than the environmental factor represented by institutional support (Bandura, 1986). Pedagogical readiness contributed significantly to deep learning implementation, whereas institutional support did not show a significant direct or mediating contribution. This result indicates that the reciprocal relationship among personal, environmental, and behavioral factors did not operate with equal strength in the Mentawai vocational school context. Teachers' professional capacity remained the most immediate factor associated with classroom and vocational learning practices.

The significant contribution of teachers' pedagogical readiness to deep learning implementation indicates that teachers with stronger instructional planning, classroom management, formative assessment, and reflective teaching skills are better positioned to facilitate meaningful and student-centered learning. The coefficient obtained for this relationship ($\beta = 0.330$, $p = 0.034$) demonstrates a positive association between pedagogical competence and deep learning implementation in vocational education. This finding aligns with previous studies showing that pedagogically competent teachers are more capable of developing higher-order thinking and authentic learning experiences than those relying primarily on technological resources (Chapman et al., 2026; Li et al., 2025).

In contrast, educational technology utilization did not show a significant contribution to deep learning implementation ($\beta = 0.228$, $p = 0.053$), despite respondents reporting relatively high technology utilization ($M = 3.572$). This suggests that technology alone cannot improve learning quality without effective pedagogical integration. In the Mentawai context, digital technologies may still be used primarily for communication and content delivery rather than inquiry-based and collaborative learning. These findings support the TPACK framework, which argues that technology enhances learning only when integrated with pedagogy and content knowledge (Mishra & Koehler, 2006;Magat, 2026; Pahrudin et al., 2025). Similar conclusions have been reported by Manto et al., (2026).

The results further showed that teachers' pedagogical readiness contributed significantly to institutional support ($\beta = 0.456$, $p = 0.007$), whereas educational technology utilization did not show a significant contribution (β = 0.203, p = 0.119). This finding suggests that teachers with stronger pedagogical competence tend to perceive greater organizational support through active participation in professional collaboration and school improvement initiatives. Conversely, technology utilization appears to rely more on individual initiatives than institutional policies. This result supports Perceived Organizational Support theory, which emphasizes that employees' perceptions of organizational appreciation and concern may shape their attitudes and professional involvement (Eisenberger et al., 1986). In the educational context, leadership, professional development, and collaborative culture may strengthen teachers' perceptions of institutional support (Connolly et al., 2023; Irayanti, 2025; Trisnaningsih et al., 2026).

Institutional support did not significantly influence deep learning implementation (β = 0.037, p = 0.424) and did not mediate the effects of teachers' pedagogical readiness (β = 0.017, p = 0.429) or educational technology utilization (β = 0.007, p = 0.454). Although institutional support was perceived positively (M = 3.434), it has not yet translated into instructional practices that directly enhance classroom learning. This finding indicates that schools continue to emphasize administrative support rather than sustained instructional coaching and professional learning, consistent with the findings of Ramaila, (2025); Zhong et al., (2026).

Overall, teachers' pedagogical readiness showed a more consistent association with deep learning implementation than educational technology utilization and institutional support in vocational schools located in remote island regions. These findings highlight the need to prioritize continuous professional development in instructional design, authentic assessment, and reflective teaching while aligning educational technology utilization with pedagogical objectives. Since the model explained 27.8% of the variance in deep learning implementation, future studies should examine additional factors, including instructional leadership, teacher self-efficacy, digital competence, organizational learning culture, and student engagement. Longitudinal or mixed-methods designs may provide a more comprehensive understanding of deep learning implementation (Berglund et al., 2026; Camacho-Zuñiga et al., 2025; Sardinha & Leite, 2026).

This study has several limitations. It involved only three public vocational schools in the Mentawai Islands Regency and relied on teachers' self-reported perceptions. Classroom, workshop, and laboratory practices were not directly observed, and student learning or vocational outcomes were not measured. In addition, institutional support was assessed through teacher perceptions rather than an objective institutional audit. The cross-sectional design also limits causal interpretation. Therefore, the findings should be interpreted as predictive and associative relationships within the specific research context.

Conclusions

This study concludes that teachers' pedagogical readiness was the most consistent factor associated with deep learning implementation in public vocational schools in the Mentawai Islands Regency. Pedagogical readiness contributed significantly to both deep learning implementation and institutional support, whereas educational technology utilization and institutional support showed no significant direct or mediating contributions. These findings emphasize the importance of strengthening teachers' pedagogical competence through continuous professional development while aligning educational technology utilization and institutional support with instructional objectives. Future studies should incorporate additional variables, objective measures, and broader research designs to provide a more comprehensive understanding of deep learning implementation in vocational education.

References

Andriyani, D. A., Prayitno, H. J., Minsih, M., Jamali, A., Damayanti, V. S., Dipsatara, T., & Pradana, F. G. (2025). Opportunities and challenges for the development of deep learning in vocational schools: drivers of learning innovation in the industrial era 4.0. Journal of Deep Learning, 95–108.

Berglund, A., Otermans, P. C. J., & Aditya, D. (2026). GenAI-Enabled AI Teachers and Student Learning Engagement Across International Higher Education Contexts. Education Sciences, 16(4). https://doi.org/10.3390/educsci16040600

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall.

Camacho-Zuñiga, C., Salas-Maxemín, S., Valle-Arce, A. P., Caratozzolo, P., & Chans, G. M. (2025). Toward a continuous learning educational model: insights from the experience of a Mexican private university. Frontiers in Education, 10. https://doi.org/10.3389/feduc.2025.1485034

Cambeses-Franco, C., & Cambeses-Franco, P. (2026). A country-level preparedness index for digital education: infrastructure, teacher scientific-technology competence, and socioeconomic context. Education and Information Technologies. https://doi.org/10.1007/s10639-026-14042-9

Chapman, B. L., Ross, A. S., & Petraki, E. (2026). Teacher readiness for generative AI: A Theory of Planned Behaviour approach. Social Sciences and Humanities Open, 13. https://doi.org/10.1016/j.ssaho.2025.102351

Connolly, C., Carr, E., & Knox, S. (2023). Diving deep into numeracy, cross-curricular professional development. International Journal of Mathematical Education in Science and Technology, 54(6), 1034–1053. https://doi.org/10.1080/0020739X.2021.1986160

Eisenberger, R., Huntington, R., Hutchison, S., & Sowa, D. (1986). Perceived organizational support. *Journal of Applied Psychology, 71*(3), 500–507.

Fitrah, M., Sofroniou, A., Yarmanetti, N., Ismail, I. H., Anggraini, H., Nissa, I. C., Widyaningrum, B., Khotijah, I., Kurniawan, P. D., & Setiawan, D. (2025). Are teachers ready to adopt deep learning pedagogy? The role of technology and 21st-century competencies amid educational policy reform. Education Sciences, 15(10), 1344.

Grustan, K. J. C., Grustan, M. C., & Buniel, J. M. C. (2026). Modeling the Influence of e-Learning Usability on National Competency Assessment Readiness among Technical-Vocational and Industrial Technology Students in the Philippines. International Journal of Information and Education Technology, 16(5), 1186–1195. https://doi.org/10.18178/ijiet.2026.16.5.2587

Halomoan, Hakiki, M., Putra, B. A. W., Hamid, M. A., Utami, R., Saputro, I. N., Azizah, W. A., Sabir, A., Hidayah, Y., & Yassin, A. (2026). Deep Learning Methods Towards a Pedagogical Framework and Implementation Strategy: A Study of Information Technology Education Curriculum Development in Indonesia. Journal of Teaching and Learning, 20(1), 185–205.

Inderanata, R. N., & Sukardi, T. (2023). Investigation study of integrated vocational guidance on work readiness of mechanical engineering vocational school students. Heliyon, 9(2).

Irayanti, I. (2025). Teachers' readiness and pedagogical change in curriculum reform: why dialogic and critical pedagogy fail to take root in Indonesian primary schools. Asian Education and Development Studies, 1–22. https://doi.org/10.1108/AEDS-11-2025-0593

Isnaeni, F., Budiman, S. A., Nurjaya, N., & Mukhlisin, M. (2025). Analysis of the Readiness for Implementing Deep Learning Curriculum in Madrasah from the Perspective of Educators. Attadrib: Jurnal Pendidikan Guru Madrasah Ibtidaiyah, 8(1), 15–30.

Istiningsih, I. (2022). Impact of ICT integration on the development of vocational high school teacher TPACK in the digital age 4.0. World Journal on Educational Technology: Current Issues, 14(1), 103–116.

Kajan, K., Shi, W., Wanatowski, D., & Ryan, M. (2026). Navigating the Dual-View Phenomenon: Social Ambivalence, Ambivalence Literacy, and Lecturer Role Transformation in AI-Integrated Transnational STEM Education. Education Sciences, 16(4). https://doi.org/10.3390/educsci16040554

Li, Y.-F., Wang, Z., Wang, L., & Guo, F. (2025). Integrating machine learning and big data analytics in an industrial engineering curriculum: Insights from an application-driven course and student feedback. TALE 2025 - 2025 IEEE International Conference on Teaching, Assessment, and Learning for Engineering, Proceedings. https://doi.org/10.1109/TALE66047.2025.11346751

Magat, R. B. (2026). From Plans to Practice: Preservice Mathematics Teachers' Journey to Conceptual Understanding. Australian Journal of Teacher Education, 51(1), 104–122. https://doi.org/10.14221/1835-517X.7172

Manto, A., Visitacion, M. A., Yee, A. M., Roble, J., Capuyan, S. N., Hermoso, F., Milano, M. L., Gonzales, R., Hallarte, D. K., & Gonzales, G. (2026). AI integration in mathematics education: A systematic review of implementation challenges and pedagogical implications (2017-2025). Social Sciences and Humanities Open, 14. https://doi.org/10.1016/j.ssaho.2026.103147

Marín-Rodríguez, N. J., Morán, B. V. G., & Gerardou, F. S. (2025). Scientometric analysis of active learning and authentic assessment between 2002 and 2024: Recent trends and further research. In The Emerald Handbook of Active Learning For Authentic Assessment. https://doi.org/10.1108/978-1-83797-857-120251002

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Mpuangnan, K. N. (2024). Teacher preparedness and professional development needs for successful technology integration in teacher education. Cogent Education, 11(1), 2408837.

Pahrudin, A., Irwandani, Aridan, M., & Barata, M. F. (2025). Teacher Readiness for Deep Learning in Islamic Education: A Rasch Model Analysis of Challenges and Opportunities. Journal of Teaching and Learning, 19(4), 262–283. https://doi.org/10.22329/jtl.v19i4.9573

Pan, T., & Jiang, L. (2025). Tech-Enhanced Learning: Evaluating General Education in Vocational Colleges Through Technology Integration: T. Pan and L. Jiang. The Asia-Pacific Education Researcher, 34(4), 1245–1255.

Pasi, B. N., & Dhamak, P. (2026). Transforming higher education for the fourth industrial revolution: a strategic review of digital integration and institutional readiness. Journal of Science and Technology Policy

Management, 1–29.

Ponnupillai, A., Earnest, B. S. P., Madhavan, P., Phyu, K. P., Sear, L. Y., Ponnupillai, A., & Thein, W. M. (2025). Bridging the gap between AI and medical education: Current implications and future perspectives. AIP Conference Proceedings, 3257(1). https://doi.org/10.1063/5.0264960

Purnama, M. R., Adnyana, I. P. I. K., Sogen, A. T. L., Indrawan, G., & Santosa, M. H. (2025). Teacher's readiness toward artificial intelligence in the school of North Bali. Jurnal Paedagogy, 12(1), 23–32.

Ramaila, S. (2025). Harnessing Project-Based and Experiential Learning for Competency-Driven Education. In Developing Teaching Competencies for Pedagogical and Curricular Innovation. https://doi.org/10.4018/979-8-3373-3566-7.ch004

Riani, A., & Sujarwati, I. (2025). The preparedness of English teachers to implement deep learning in middle school. Educasia: Jurnal Pendidikan, Pengajaran, Dan Pembelajaran, 10(2), 229–244.

Sardinha, M., & Leite, M. (2026). Implementing a project-based learning framework for teaching additive manufacturing: drivers, enablers and outcomes. Procedia CIRP, 142, 692–697. https://doi.org/10.1016/j.procir.2026.05.331

Subiyantoro, S., Musa, M. Z., & Efendi, A. (2024). Preparing Indonesian primary school teachers for deep learning: Readiness, challenges, and institutional support. Cognitive Development Journal, 2(2), 77–86.

Suherman, A., Supriyadi, T., Safari, I., Saptani, E., Fauzi, R. A., Sudirjo, E., Komiljon O'g'li, T. S., & Abdisamiyevich, X. J. (2025). Bridging Teacher Readiness and Deep Learning-Based Teaching Practice: Assessing the Effectiveness of the ACTIVE Model for Enhancing Teacher Pedagogy. International Research Journal of Multidisciplinary Scope, 6(4), 284–298. https://doi.org/10.47857/irjms.2025.v06i04.05526

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Trisnaningsih, S., Sukmawati, F., Santosa, E. B., Ridhani, J., & Qodr, T. S. (2026). Exploring teacher's acceptance of online assessment to support deep learning pedagogy: An integrated UTAUT2 approach. Multidisciplinary Reviews, 9(5). https://doi.org/10.31893/multirev.2026259

Utomo, J. B., Prayitno, H. J., & Indri, I. (2025). Strategies and Development of the Deep Learning Approach in Vocational High Schools in the Era of Global Computing. Journal of Deep Learning, 1–10.

Wahyuningsih, R., Joyoatmojo, S., Wardani, D. K., & Noviani, L. (2025). Work-integrated learning to improve work readiness of vocational education in school and madrasah. Munaddhomah: Jurnal Manajemen Pendidikan Islam, 6(4), 586–602.

Waloyo, W., Prayitno, H. J., Toharudin, T., & Rahmawati, Y. (2026). Teacher readiness for deep learning implementation in Indonesian education: A systematic narrative review of dimensions, barriers, and enabling factors. Journal of Deep Learning, 67–82.

Yulin, N., & Danso, S. D. (2025). Assessing pedagogical readiness for digital innovation: A mixed-methods study. ArXiv Preprint ArXiv:2502.15781.

Zary, A., & Zary, N. (2025). Artificial intelligence in technical and vocational education and training: Empirical evidence, implementation challenges, and future directions.

Zhong, H., Peng, L., Zhou, X., Lei, F., Ren, H., & Wang, L. (2026). A Project-Based Learning for Intelligent Systems: A Case Study in Developing Integrative Engineering Competencies. Computer Applications in Engineering Education, 34(4). https://doi.org/10.1002/cae.70233