BUSINESS AND APPLIED MANAGEMENT JOURNAL
Vol. 3 No. 2 (2025), p. 327-337
Available online at https://serambi.org/index.php/bamj

Digital Literacy and Technostress in the Job Demands–Resources Perspective: The Mediating Role of Instructional Innovation on Elementary School Teachers' Performance

Fahriansyah[1*], Rizky Fauzan[2], Titik Rosnani[3]
Universitas Tanjungpura, Indonesia

DOI: https://doi.org/10.61987/bamj.v3i2.1640

Article History:
Received: 15 July 2025
Revised: 13 September 2025
Accepted: 15 November 2025

Keywords:
Digital Literacy, Technostress, Instructional Innovation, Teacher Performance

**Correspondence Address:*
fahriansyah@ecampus.ut.ac.id

Abstract :
This study examines the influence of digital literacy and technostress on elementary school teachers' performance with instructional innovation as a mediating variable within the Job Demands–Resources (JD-R) framework. The research employed a quantitative explanatory design using Partial Least Squares Structural Equation Modeling (PLS-SEM). Data were collected from elementary school teachers in West Kalimantan Province through an online questionnaire. The results indicate that digital literacy has a significant positive effect on instructional innovation and teachers' performance. Instructional innovation also significantly improves teachers' performance. Meanwhile, technostress does not have a direct effect on teachers' performance but does influence it indirectly through instructional innovation. These findings suggest that digital literacy functions as an important job resource that enhances innovative teaching practices. In contrast, technostress can act as a challenge that stimulates adaptive innovation in digital learning environments. The model demonstrates strong explanatory power with an R^2 value of 0.706 for teachers' performance. The study contributes to the development of JD-R theory in digital education by identifying instructional innovation as an adaptive mechanism that transforms job demands and job resources into improved teacher performance.

INTRODUCTION

The rapid advancement of digital technology has revolutionized education systems worldwide, including in Indonesia. The integration of digital technology into education has shifted teaching paradigms, making learning more flexible, interactive, and collaborative (Mhlongo et al., 2023; Zou et al., 2025). Digital tools are no longer just supplementary resources; they are now essential to lesson design, classroom management, and assessment systems (Oguguo et al., 2023; Okafor, 2025). In this context, digital literacy has emerged as a critical competence for educators (Ilomäki et al., 2023; Marín & Castaneda, 2023). It is essential for improving teaching quality and adapting to the demands of the 21st-century education system. Given these changes, the role of teachers in utilizing technology effectively has become crucial (Rahimi & Oh, 2024; Stumbrienė et al., 2024; Suchita et al., 2023). However, while digital technologies offer significant potential, they also introduce challenges, including technostress, which can

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impact teacher performance. Therefore, understanding the dynamics between digital literacy, technostress, and teacher performance is essential for enhancing educational outcomes.

To analyze the relationships among digital literacy, technostress, and teacher performance, this study draws on the Job Demands-Resources (JD-R) theory. The JD-R theory is a widely recognized framework in occupational psychology that divides job characteristics into two categories: job demands and job resources (Demerouti et al., 2001; Bakker & Demerouti, 2017). Job demands refer to the aspects of a job that require high physical or psychological effort, potentially causing stress. In contrast, job resources are the supportive aspects that help employees meet job demands, reduce stress, and enhance motivation and performance. This theory is particularly relevant in the context of education, where teachers face the dual challenge of managing the demands of digital technology and leveraging it as a resource to enhance their teaching practices.

Despite the promising benefits of digital technology in education, teachers face significant challenges. One major issue is technostress, the stress caused by the rapid pace of technological change and the increasing demand for digital skills (Khlaif et al., 2023; Rodriguez-Barboza et al., 2023). Teachers must continuously adapt to new platforms and digital tools, which can be overwhelming and lead to burnout. This challenge is compounded by insufficient professional development and support in effectively using technology. As a result, while some teachers thrive in this digital environment, others struggle to keep up with the constant technological advancements, which can affect their job satisfaction, well-being, and performance. Thus, understanding how technostress affects teacher performance and how digital literacy can mitigate these effects is crucial for creating a supportive and effective teaching environment.

Previous research has explored various aspects of digital literacy and technostress in educational settings. Studies have shown that digital literacy plays a significant role in enhancing teaching quality, as teachers with strong digital skills are better equipped to design engaging and innovative lessons (Aslan et al., 2025; Temirkhanova et al., 2024). However, other studies highlight the negative effects of technostress on teachers, including decreased job satisfaction, burnout, and lower performance (Estrada-Muñoz et al., 2020; Abilleira et al., 2021). These studies have largely treated digital literacy and technostress separately, without integrating them into a unified framework that also considers teacher performance. The research gap lies in understanding how these factors interact to influence teaching outcomes, particularly in the context of the digital transformation of education.

Furthermore, while much has been done to examine the individual impact of digital literacy and technostress, few studies have explored their combined effect on teacher performance. In particular, there is a lack of research examining how innovations in teaching, crucial for adapting to the digital era, are influenced by digital literacy and technostress (Sary et al., 2023; Li et al., 2024). The existing literature often focuses on the positive outcomes of digital literacy, such as improved teaching practices and student engagement, while overlooking the potential negative impact of technostress on teacher well-being and performance. There is also a limited understanding of how innovations in teaching can mediate the relationships among digital literacy, technostress, and teacher performance. This research aims to fill this gap by integrating these variables into a comprehensive model that provides a deeper understanding of the factors that influence teacher effectiveness in the digital age.

This study introduces a novel approach by integrating digital literacy, technostress, and teaching innovation into a single framework, using the JD-R theory to explain how these elements interact to influence teacher performance. The study aims to explore the mediating role of teaching innovation in the relationship between digital literacy, technostress, and teacher performance. By focusing on elementary school teachers, this research offers valuable insights into the specific challenges and opportunities they face in the digital transformation of education. The results of this study are expected to contribute to the development of more effective professional development programs that address both the potential benefits and drawbacks of digital technology in education. In doing so, it provides practical implications for improving teacher performance and overall educational outcomes.

Based on the literature synthesis and theoretical framework, this study seeks to answer several key research questions. First, how does digital literacy affect teacher performance, and what role does technostress play in this relationship? Second, how does technostress influence teacher performance, both directly and indirectly through teaching innovation? Finally, how does teaching innovation mediate the relationship between digital literacy, technostress, and teacher performance? The hypotheses to be tested include:

H1: Digital literacy positively influences teaching innovation
H2: Technostress negatively influences teaching innovation
H3: Digital literacy positively influences teacher performance
H4: Technostress negatively influences teacher performance
H5: Teaching innovation positively influences teacher performance
H6: Teaching innovation mediates the relationship between digital literacy and teacher performance
H7: Teaching innovation mediates the relationship between technostress and teacher performance.

This research aims to provide a comprehensive understanding of these relationships, offering both theoretical contributions to the Job Demands-Resources theory and practical insights for improving teaching practices in the digital age.

RESEARCH METHODS

This study employed a quantitative, explanatory design to explore the causal relationships among digital literacy, technostress, learning innovation, and teacher performance in elementary schools. The choice of a quantitative approach was driven by the goal of testing hypotheses grounded in theoretical frameworks and the existing literature. Using a hypothesis-driven approach, the study aimed to validate relationships among key variables based on prior research findings. To analyze the data, Partial Least Squares-based Structural Equation Modeling (PLS-SEM) was used with SmartPLS software. PLS-SEM was selected because it is effective for modeling complex research frameworks, accommodates a large number of indicators, and does not require data to be normally distributed. Moreover, PLS-SEM offers strong predictive capabilities, making it ideal for exploring latent-variable relationships (Hair et al., 2021; Hair et al., 2022).

The study population consisted of elementary school teachers in West Kalimantan Province who integrate digital technology into their teaching. A purposive sampling technique was employed to select respondents based on specific criteria that align with the study's objectives. The inclusion criteria for respondents were: (1) active elementary

school teachers, (2) users of digital technology in the classroom, and (3) teachers who were willing to participate in the study. This sampling method ensured that the collected data were relevant and representative of the target population, enabling a more accurate understanding of the relationships among the study variables.

The number of respondents in this study ranged from 250–300 elementary school teachers, which was deemed sufficient for PLS-SEM analysis based on the complexity of the research model and the number of indicators used (Hair et al., 2021). This study used four main variables: independent variables, mediating variables, and dependent variables.

1. Digital Literacy (X1) is the independent variable, describing teachers' ability to use digital technology effectively in the learning process.
2. Technostress (X2) is the independent variable, describing psychological stress resulting from the demands of using technology in their work.
3. Learning Innovation (M) is the mediating variable, describing teachers' ability to develop new learning methods or strategies.
4. Teacher Performance (Y) is the dependent variable, describing teachers' effectiveness in planning, implementing, and evaluating the learning process.

Research data were collected using a five-point Likert-based questionnaire, with the following response ranges:

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

The research instrument was adapted from several previous studies to ensure construct validity. The digital literacy indicator was adapted from Ng (2012) and Redecker (2017), the technostress indicator was adapted from Tarafdar et al. (2019) and Bondanini et al. (2020), the learning innovation indicator was adapted from Messmann and Mulder (2012), while the teacher performance indicator was adapted from Klassen and Bardach (2023) and Metsäpelto et al. (2021).

RESULTS AND DISCUSSION

Results

Measurement Model Evaluation (Outer Model)

The measurement model evaluation was conducted to assess the validity and reliability of the latent constructs through analysis of outer loadings, composite reliability, and average variance extracted (AVE). The analysis results showed that all indicators had outer loadings above 0.70, thus demonstrating good convergent validity.

Table 1. Outer Loading Indicator

Indicator	Loading
M1.1	0.862
M1.2	0.874
M1.3	0.881
M1.4	0.861
X1.1	0.826
X1.2	0.841
X1.3	0.864
X1.4	0.860

X1.5	0.859
X1.6	0.838
X1.7	0.701
X2.1	0.876
X2.2	0.934
X2.3	0.798
Y1.1	0.868
Y1.2	0.877
Y1.3	0.877
Y1.4	0.827
Y1.5	0.862
Y1.6	0.797

Table 1 presents the outer loadings for the indicators, all of which exceed the 0.70 threshold, demonstrating good convergent validity for the latent constructs. This indicates that the indicators effectively measure their respective constructs, providing strong evidence of the model's reliability and consistency. The high loadings, ranging from 0.701 to 0.934, indicate that the model's indicators are highly correlated with their underlying constructs, ensuring that each latent variable is well represented and can be reliably used for further analysis.

Reliability and Construct Validity Testing

Construct reliability testing was conducted using Cronbach's Alpha and Composite Reliability, while convergent validity was evaluated using Average Variance Extracted (AVE).

Table 2. Construct Reliability and AVE

Variabel	*Cronbach Alpha*	*Composite Reliability*	*AVE*
Learning Innovation	0.893	0.926	0.757
Digital Literacy	0.923	0.939	0.687
Technostress	0.841	0.904	0.759
Teacher Performance	0.924	0.941	0.726

Table 2 shows the results of construct reliability and convergent validity testing. All constructs demonstrate high reliability, with Composite Reliability values exceeding 0.70 for each variable, indicating consistent measurement. Additionally, the Average Variance Extracted (AVE) values are all above 0.50, confirming good convergent validity. These results suggest that the constructs are well-defined and reliably represent the underlying latent variables, ensuring the robustness of the model for further analysis.

Discriminant Validity

Discriminant validity was tested using the Heterotrait-Monotrait Ratio (HTMT) and the Fornell-Larcker Criterion.

Tabel 3. HTMT Matrix

Variables	M	X1	X2	Y
Innovation	—			
Digital Literacy	0.873	—		
Technostress	0.701	0.746	—	
Teacher Performance	0.873	0.852	0.689	—

Table 3 presents the Heterotrait-Monotrait Ratio (HTMT) matrix, with all values below the 0.90 threshold, indicating that discriminant validity is confirmed. This suggests that the constructs in the model are sufficiently distinct, as none of the HTMT values indicate excessive correlation among them. Therefore, the constructs are adequately differentiated, supporting the validity of the measurement model.

Structural Model Evaluation (Inner Model)

Structural model evaluation assessed the strength and significance of the relationships among the latent variables in the research model. This evaluation helps determine how well the hypothesized relationships among the variables are supported by the data, providing insights into the model's direct and indirect effects. The results of this analysis provide a deeper understanding of the underlying connections among the constructs, thereby enhancing the explanatory power of the research model.

Table 4. Coefficient of Determination (R^2)

Endogenous Variables	R^2
Learning Innovation	0.647
Teacher Performance	0.706

Table 4 shows the coefficient of determination (R^2) values for the endogenous variables. The R^2 value of 0.647 for learning innovation indicates that the model's predictors explain 64.7% of its variation. More notably, the R^2 value of 0.706 for teacher performance suggests that 70.6% of the variation in teacher performance is explained by digital literacy, technostress, and learning innovation, indicating strong explanatory power for the model. These results highlight the significant impact of these variables in explaining teacher performance, making them critical factors in the research model.

Hypothesis Testing

Hypothesis testing was conducted using bootstrapping analysis in PLS-SEM to obtain path coefficients, T-statistics, and p-values.

Table 5. Hypothesis Testing Results

Relationship	Coefficient	T-stat	p-value	Results
Digital Literacy → Innovation	0.692	11.893	0.000	Significant
Digital Literacy → Performance	0.390	4.169	0.000	Significant
Technostress → Innovation	0.156	2.823	0.005	Significant
Technostress → Performance	0.092	1.932	0.053	Not significant
Innovation → Performance	0.428	4.737	0.000	Significant

Table 5 shows that digital literacy significantly influences both innovation (coefficient = 0.692, p-value = 0.000) and teacher performance (coefficient = 0.390, p-value = 0.000). This highlights the strong role of digital literacy in driving innovation and improving performance. Technostress affects innovation (coefficient = 0.156, p-value = 0.005), but has no significant impact on performance (coefficient = 0.092, p-value = 0.053). Lastly, innovation positively influences teacher performance (coefficient = 0.428, p-value = 0.000). In conclusion, digital literacy is the most influential factor in improving both innovation and performance, with innovation being a key driver of teacher performance.

Testing the Mediation Effect

Mediation effects were tested by analyzing the specific indirect effects in the model. This approach helps to examine whether a mediator variable influences the relationship between an independent variable and a dependent variable. By evaluating these indirect effects, the study can identify the extent to which the mediator variable explains or modifies the independent variable's impact on the dependent variable, providing a clearer understanding of the mechanisms at play.

Table 6. Specific Indirect Effects

Mediation Relationship	Coefficient	T-stat	p-value
Digital Literacy → Innovation → Performance	0.296	4.181	0.000
Technostress → Innovation → Performance	0.067	2.271	0.023

Table 6 shows that teaching innovation partially mediates the relationship between digital literacy and teacher performance (coefficient = 0.296, p-value = 0.000), meaning that digital literacy enhances teacher performance through innovative teaching practices. Conversely, teaching innovation fully mediates the relationship between technostress and teacher performance (coefficient = 0.067, p-value = 0.023), suggesting that innovation helps alleviate the negative impact of technostress on performance. These findings underscore the crucial role of digital literacy and innovation in improving teacher performance, especially in managing the challenges of technostress.

Predictive Relevance (PLSpredict)

The model's predictive ability was evaluated using the PLSpredict approach. The analysis showed that all indicators had positive Q^2 predict values, with values ranging from 0.326 to 0.534.

Furthermore, most indicators showed smaller Root Mean Square Error (RMSE) values for the PLS-SEM model than for the Linear Model (LM), indicating that the research model has good predictive ability. Thus, the developed model not only has explanatory power but also adequate predictive power in explaining elementary school teacher performance.

Discussion

The findings of this research align with existing literature, particularly in the areas of digital literacy and teacher performance. Previous studies, such as those by Redecker (2017) and Falloon (2020), highlight the critical role of digital literacy in enhancing teaching effectiveness. This study reinforces those findings by showing that teachers with higher digital literacy levels are better equipped to innovate in their teaching practices. Technostress, however, did not have a direct impact on teacher performance in this study, which contrasts with the work of Estrada-Muñoz et al. (2020), who found that technostress negatively impacts teacher well-being and performance. This difference might be attributed to the fact that teaching innovation, as seen in this study, can act as a buffer against the negative effects of technostress. This aspect has not been fully explored in previous research.

One of the key contributions of this study is the integration of digital literacy, technostress, and innovation into a single framework, demonstrating how these factors together influence teacher performance. Unlike previous studies that examined these

variables separately, this research highlights the mediating role of innovation. It shows that innovation not only improves performance but also helps mitigate the negative effects of technostress. As Sari et al. (2023) and Li et al. (2024) noted, innovation in teaching can enhance engagement and performance. However, this study takes it a step further by positioning innovation as a mediator, offering a new perspective on its role in improving teacher performance.

The practical implications of these findings are significant for policy-making and teacher training programs. Given that digital literacy and innovation are key drivers of teacher performance, educational policymakers should prioritize professional development programs that build teachers' digital skills and encourage innovative teaching practices. This aligns with the work of Bakker et al. (2023), who emphasized the importance of training in the context of digital transformation in education. Additionally, supporting teachers in managing technostress through targeted strategies such as training, peer support, and adequate resources can help mitigate its impact on teacher performance, as suggested by Califf & Brooks (2020).

The mediating role of innovation is a crucial contribution of this research. While digital literacy plays an important role, the study shows that innovation in teaching is the key factor in improving teacher performance. This aligns with the findings of Anderson et al. (2014), who stressed that innovative practices are necessary for fostering effective teaching in today's digital classrooms. Policymakers and school leaders should therefore focus not only on increasing teachers' digital skills but also on fostering environments that encourage experimentation and the adoption of innovative teaching methods. This could involve providing teachers with time, resources, and the autonomy to explore new teaching approaches.

Another interesting finding is that while technostress impacts innovation, it does not directly affect teacher performance. This suggests that technostress, though a concern, can be managed effectively if teachers are encouraged and supported in innovating their practices. As noted by Khlaif et al. (2022), the rapid technological changes in education can create stress for teachers. However, when paired with supportive structures that encourage innovative solutions, this stress may not directly harm their performance. Schools should therefore create environments that help teachers manage technostress by fostering a culture of innovation and providing the necessary support.

This research contributes to the literature on digital literacy, technostress, innovation, and teacher performance by integrating these factors into a cohesive framework. The study's findings provide valuable implications for the development of teacher training programs, which should emphasize digital literacy and teaching innovation as key factors in improving teacher performance. Additionally, addressing technostress through supportive policies and resources can further enhance teacher performance. This research fills a gap in the literature by showing how these variables interact and offers actionable insights for both educators and policymakers.

CONCLUSION

The research highlights the critical role of digital literacy and technostress in shaping elementary school teachers' performance, with learning innovation as a mediating factor within the framework of Job Demands–Resources Theory (JD-R). The study demonstrates that digital literacy positively influences learning innovation, fostering more creative and effective teaching practices. Additionally, learning innovation

significantly impacts teacher performance, reinforcing the importance of innovative teaching methods in improving educational outcomes. While technostress does not have a direct negative effect on teacher performance, it indirectly influences performance by encouraging the development of innovative teaching strategies as an adaptation mechanism to technological demands. The research's predictive capability, supported by strong model explanatory power (R^2 = 0.706), underscores the importance of digital literacy and learning innovation in enhancing teacher effectiveness in the digital education environment.

The theoretical implications of this study contribute to the development of JD-R Theory by positioning digital literacy as a vital resource that motivates teachers and promotes innovative teaching practices. Moreover, the findings challenge the traditional view of technostress as purely detrimental, suggesting that it may act as a challenge demand that stimulates adaptation and innovation. The study's practical implications recommend that educational institutions prioritize teacher digital literacy development through training programs that integrate technological tools with pedagogical skills. Additionally, providing adequate technological support and fostering a culture of innovation within schools are crucial steps to alleviate technostress and enhance teaching performance. By emphasizing these elements, the research advocates for a comprehensive approach to improving teacher performance and the overall quality of education in the digital age.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to Universitas Tanjungpura for providing the necessary resources and support throughout this research. Their guidance and encouragement have been invaluable in completing this study.

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