Enhancing Digital Learning Outcomes: The Combined Impact of Competence and Psychological Traits

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Article Info	Abstract
	The rapid shift towards digitalization, accelerated by the COVID-19 pandemic, requires a reassessment of problem-solving strategies in the education system. This study aims to investigate the interactions between Digital Competencies, Psychological Traits, Digital Readiness, and Awareness, and their combined influence on Learning Outcomes. The study utilized a quantitative, cross-sectional design, focusing on university students engaged in digital learning environments in higher education. Data were collected from 467 students through a validated online questionnaire and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results revealed that Digital Competence and Psychological Traits significantly and positively influence Learning Outcomes, both directly and indirectly through the mediating role of Digital Readiness and Awareness. The findings emphasize the need for a holistic approach in education, which integrates technical skills and psychological readiness to enhance academic success in an increasingly digital learning environment. This study also highlights the need for further research with a longitudinal design to explore the long-term effects of digital competency and awareness interventions. Recommendations for future research include examining additional factors such as social support and technology access to further strengthen digital readiness and learning outcomes.

INTRODUCTION

The rapid digitalization of education, accelerated by the COVID-19 pandemic, has not only reshaped learning environments but also highlighted the urgent need to adapt problem-solving strategies within the education system. In this context, digital competency emerges as a pivotal skill, encompassing the ability to effectively utilize digital technologies for learning, communication, and information management. This competency is indispensable for equipping students to navigate the complexities of modern education and meet the evolving demands of a digitalized workforce (Syahrin et al., 2023). Furthermore, psychological traits such as emotional intelligence and resilience play a critical role in shaping how students interact with digital tools and adapt to dynamic learning environments. Together, these factors significantly influence learning outcomes, underscoring the need for an integrative approach that addresses both technical and psychological readiness in digital education (Gugliandolo et al., 2015).

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The field has advanced significantly, underscoring the importance of digital readiness and psychological traits, including self-efficacy, emotional stability, and mindfulness, in education. Research has shown that self-efficacy improves engagement and persistence, emotional stability enhances resilience in digital learning environments, and mindfulness reduces stress and fosters focus, all of which are vital for student adaptability (Chiş et al., 2024; Abdelfattah et al., 2023; Vu, 2023). However, challenges such as disparities in access and inadequate psychological support underscore the need for further integrative strategies to maximize the benefits of digital education (Digamo & Abuzo, 2024).

The need to address these interrelated factors is further amplified by the challenges associated with the digital divide and varying levels of digital readiness among students. The pandemic has exacerbated existing inequalities in access to technology and online learning resources, especially for students in remote areas (- Lie et al., 2020). This emphasizes the need for targeted interventions to improve digital readiness and ensure that all students have equal learning opportunities (Luthfiyah et al., 2022). Furthermore, integrating mindfulness practices into educational settings has been shown to improve students' focus, emotion regulation, and overall well-being, which in turn positively impacts learning outcomes (Furió et al., 2015).

Despite growing research on digital competencies, psychological traits, and learning outcomes, their interconnectedness remains underexplored. Most studies address these constructs separately, focusing on digital skills without considering the mediating role of traits like self-efficacy and mindfulness (Li & Liu, 2022; Aisyah et al., 2023). Evidence suggests mindfulness enhances psychological well-being, improving engagement with digital tools and adaptability in learning environments (Guertin et al., 2023; Wang, 2019). This underscores the need for integrative studies to better inform educational strategies.

To address these challenges, a resolution plan is proposed that includes the following activity objectives: (1) investigate the relationship between digital competence and psychological traits in improving learning outcomes; (2) assess the mediating role of digital readiness in this relationship; and (3) explore the impact of mindfulness on students' adaptability to digital learning environments. The hypotheses guiding this research argue that higher levels of digital competence and positive psychological traits, when combined with mindfulness practices, will result in improved learning outcomes among students.

Research shows that mindfulness practices can significantly improve students' academic outcomes by promoting metacognitive skills and reducing anxiety. (Morris, 2003). For example, studies have shown that students who engage in mindfulness training exhibit greater academic self-efficacy and resilience, which are crucial for dealing with the challenges of academic life (Vidal-Meliá et al., 2022).

The integration of digital competencies and psychological traits is vital for enhancing educational outcomes. Digital competencies, such as using digital tools, analyzing content critically, and collaborating online, are essential for navigating digital learning environments (Chaw & Tang, 2022; Oliynyk et al., 2024; Stoika, 2023). These skills, combined with psychological traits like mindfulness, which improve focus, emotional regulation, and engagement, foster a positive learning atmosphere and better academic performance (Sarva et al., 2023; Cao et al., 2023). This highlights the need for a holistic approach that blends technical skills with psychological readiness to maximize the potential of digital education.

This study addresses a critical gap by examining the interconnected roles of digital competencies, psychological traits, and mindfulness, which are rarely explored together in existing research. Unlike prior studies that treat these factors independently, this research provides a comprehensive analysis of their synergistic impact on learning outcomes. Utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) offers a robust methodological approach, advancing knowledge in digital education.

The study aims to explore the direct and indirect effects of digital competencies and psychological traits on learning outcomes, with digital readiness and mindfulness as mediators. By doing so, it highlights the urgent need for integrated interventions that enhance both technical and psychological readiness, equipping students to adapt and succeed in increasingly complex digital learning environments. This research provides actionable insights to bridge gaps in the literature and guide educators and policymakers in fostering holistic digital education strategies.

METHOD

This study uses a quantitative approach with a cross-sectional design (Cabezas-González et al., 2023) to examine the relationship between Digital Competence, Psychological Traits, Digital Readiness and Mindfulness, and Learning Outcomes. This research focuses on students engaged in digital learning environments, particularly in higher education. Each latent variable was measured through a reflective model, with indicators designed to assess various aspects.

This study involves four variables, each measured using five main indicators: Digital Competence (DC1 to DC5); Digital Readiness and Mindfulness (DRM1 to DRM5); Psychological Traits (PT1 to PT5), and Learning Outcomes, which were also measured through five indicators (LO1 to LO5). Each variable is defined and measured to comprehensively assess its relevance and impact within the research framework. The definitions of these variables are detailed in Table 1. Table 1 is the definition of each variable.

**Table 1.** Definition Of Each Variable

Variables	Description
Digital Competence (DC)	Ability to use digital technologies effectively, including skills, motivation and ethical understanding (Jarva et al., 2023; Sánchez-Canut et al., 2023).
Psychological Traits (PT)	Innate characteristics that influence behavior and attitudes towards digital technology, such as adaptability and resilience (Ling et al., 2023; Kayser et al., 2022).
Digital Readiness and Mindfulnes (DRM)	Readiness and willingness to adopt digital technologies, which includes access, innovation capabilities, and awareness and attention that increase engagement with digital tools (Sari et al., 2023; Kini et al., 2023).
Learning Outcomes (LO)	Measurable outcomes of the education process, influenced by digital competence and readiness (Jarva et al., 2023).

Participants and data analysis

The population in this study included students majoring in informatics and computer engineering or those who integrated digital technology intensively in the learning process. The research sample consisted of 467 students who were involved using a stratified random sampling technique with data collection through an online questionnaire prepared based on a validated scale.

The research data were collected by distributing questionnaires online through Google Forms (Mondal et al., 2019). The questionnaire used a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) (Nurlia & Anggo, 2023). Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with the help of Smart PLS software (Saregar et al., 2024). At various stages of data processing, validity tests (convergent and discriminant), reliability tests, and hypothesis (significance) tests were conducted.

To illustrate the conceptual framework of this study, a proposed model was developed to examine the relationships between Digital Competence, Psychological Traits, Digital Readiness and Mindfulness, and Learning Outcomes. The model also integrates hypotheses that highlight the direct and indirect effects of these variables, as well as the mediating role of Digital Readiness and Mindfulness. The proposed model is presented in Figure 1.
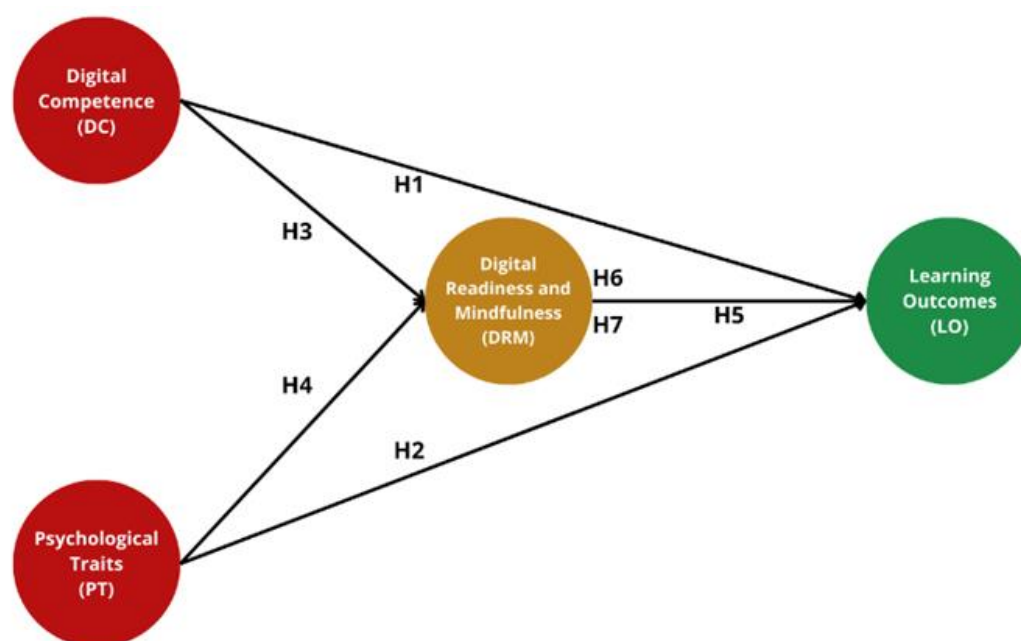
Figure 1. The Proposed Model in this Study

Hypothesis:

H1: Digital Competence has a positive and significant influence on Learning Outcomes.

H2: Psychological Traits have a positive and significant influence on Learning Outcomes.

H3: Digital Competence has a positive and significant influence on Digital Readiness and Mindfulness.

H4: Psychological Traits have a positive and significant influence on Digital Readiness and Mindfulness.

H5: Digital Readiness and Mindfulness have a positive and significant influence on Learning Outcomes.

H6: Digital Readiness and Mindfulness mediate the relationship between Digital Competence and Learning Outcomes, such that higher Digital Competence results in better Learning Outcomes through increased Digital Readiness and Mindfulness.

H7: Digital Readiness and Mindfulness mediate the relationship between Psychological Traits and Learning Outcomes, which means positive Psychological Traits improve Learning Outcomes through increased Digital Readiness and Mindfulness.

RESULTS AND DISCUSSION

The Results and Discussion section begins by presenting the main findings of the study, which explores the relationships between Digital Competence, Psychological Traits, Digital Readiness and Mindfulness, and Learning Outcomes. These constructs were measured using validated indicators to ensure they comprehensively capture their theoretical dimensions, providing a solid foundation for further analysis.

Data Validation
Convergent Validity

Convergent validity is critical in this research to confirm that the indicators within each construct consistently measure the same underlying concept. This validation ensures the reliability of the constructs and the robustness of the measurement model, which is essential for accurate hypothesis testing. Convergent validity was assessed using three key criteria: (1) outer loadings of the items, (2) Composite Reliability (CR), and (3) Average Variance Extracted (AVE). For strong convergent validity, the outer loadings should be ≥0.7, CR > 0.7, and AVE > 0.5 (Tondang, 2023; Febriyanti et al., 2024). Table 2 presents the results of construct reliability and validity.

Table 2. Construct Reliability and validity

Construct and Items	Outer Loading	Rho_A	Composite Reliability (CR)	Average Variance Extracted (AVE)
Digital Competence (DC)				
DC1	0.826			
DC2	0.844			
DC3	0.853	0.889	0.917	0.689
DC4	0.782			
DC5	0.845			
Psychological Traits (PT)				
PT1	0.814			
PT2	0.827			
PT3	0.886	0.901	0.926	0.715
PT4	0.852			
PT5	0.846			
Digital Readiness and Mindfulness (DRM)				
DRM1	0.850			
DRM2	0.813			
DRM3	0.835	0.884	0.915	0.683
DRM4	0.827			
DRM5	0.806			
Learning Outcomes (LO)				
LO1	0.868			
LO2	0.830			
LO3	0.874	0.910	0.933	0.734
LO4	0.856			
LO5	0.856			

As shown in Table 2, all constructs-Digital Competence (DC), Psychological Traits (PT), Digital Readiness and Mindfulness (DRM), and Learning Outcomes (LO)-demonstrated strong convergent validity. Outer loadings for all items exceeded the 0.7 threshold, confirming that the indicators reliably measure their respective constructs.

For example, Digital Competence (DC) achieved outer loadings between 0.782 and 0.853, with a Composite Reliability (CR) of 0.917 and an Average Variance Extracted (AVE) of 0.689, ensuring consistency in measuring the construct. Similarly, Psychological Traits (PT) showed outer loadings ranging from 0.814 to 0.886, with a CR of 0.926 and an AVE of 0.715, highlighting its strong internal consistency. Digital Readiness and Mindfulness (DRM) also demonstrated robust validity, with outer loadings between 0.806 and 0.850, a CR of 0.915, and an AVE of 0.683. Lastly, Learning Outcomes (LO) showed outer loadings between 0.830 and 0.874, with a CR of 0.933 and an AVE of 0.734, confirming its reliability in capturing students' academic performance and understanding.

These findings validate the robustness of the measurement model, ensuring the constructs are suitable for hypothesis testing and structural analysis. The strong convergent validity across constructs highlights the reliability of the indicators and provides a solid foundation for understanding how digital competencies and psychological traits influence learning outcomes within the framework of digital readiness and mindfulness.

Discriminant Validity

Discriminant validity ensures that each construct in the model measures a unique concept and does not overlap with others. This validation is crucial for confirming the robustness of the measurement model and ensuring that constructs represent distinct theoretical dimensions. In this study, discriminant validity was assessed using the Heterotrait-Monotrait Ratio (HTMT), with a threshold of 0.90 indicating sufficient distinction between constructs (Fatimah et al., 2023). Table 3 presents the results of the discriminant validity test using the HTMT criterion.

Table 3. Heterotrait-Monotrait Ratio (HTMT)

	DC	DRM	LO	PT
DC				
DRM	0.871			
LO	0.843	0.761		
PT	0.820	0.759	0.830	

As shown in Table 3, all HTMT values are below 0.90, confirming strong discriminant validity. For instance, the HTMT value between Digital Competence (DC) and Digital Readiness and Mindfulness (DRM) is 0.871, indicating a clear distinction. Similarly, the HTMT values between Digital Competence (DC) and Learning Outcomes (LO) (0.843) and between Digital Competence (DC) and Psychological Traits (PT) (0.820) further confirm their uniqueness. Other constructs, such as Digital Readiness and Mindfulness (DRM) and Learning Outcomes (LO) (0.761), also demonstrate sufficient differentiation.

These results validate that each construct in the model is distinct and accurately captures its theoretical dimension. This strong discriminant validity ensures the integrity of the measurement model and provides a reliable foundation for analyzing relationships between constructs in the structural model, thereby strengthening confidence in the study's findings.

Model Analysis

Structural model analysis using Partial Least Squares Structural Equation Modeling (PLS-SEM) provides significant insights into the relationship between variables (Liswanda et al., 2024). The results of this test provide insight into the strength and significance of the relationships proposed in the model. Figure 2 illustrates the structural model tested in this study.
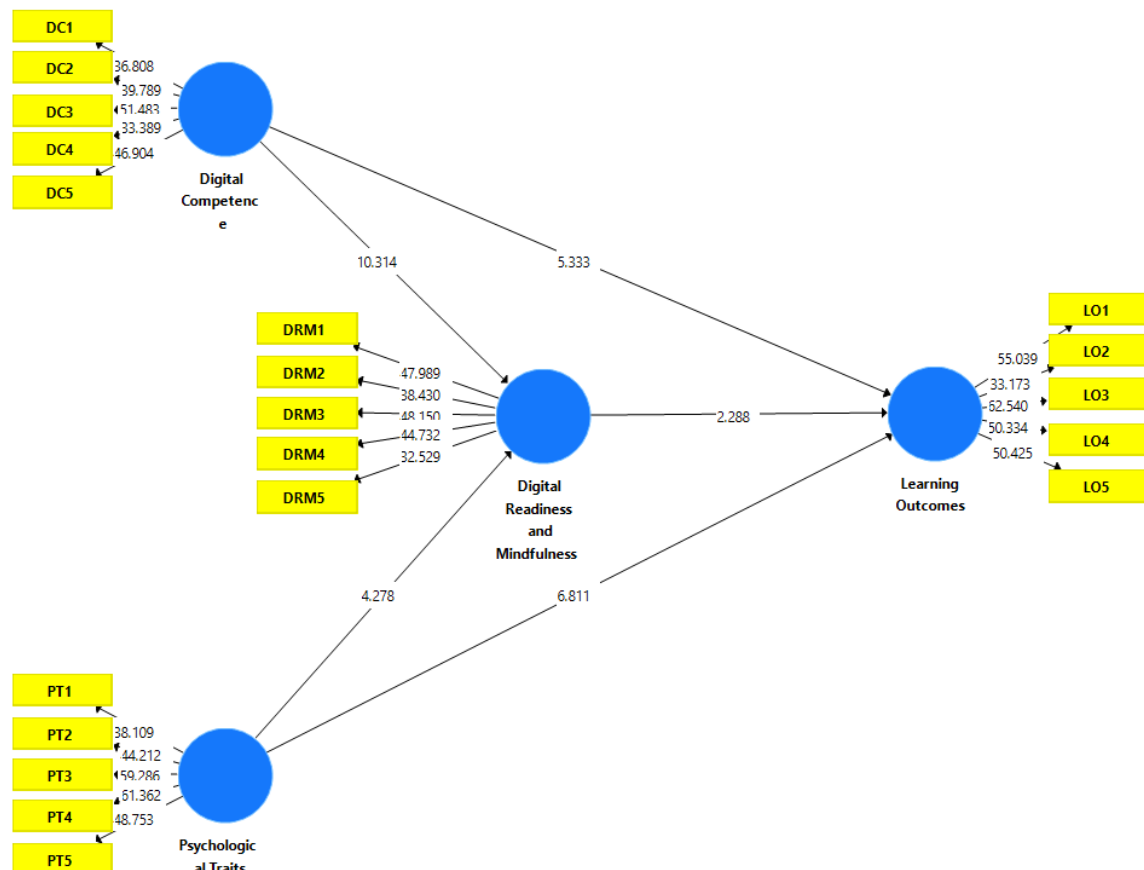
Figure 2. Structural Modeling

Hypothesis Testing

Hypothesis testing in this study evaluates the relationship between the constructs-Digital Competence, Psychological Traits, Digital Readiness and Mindfulness, and Learning Outcomes through path coefficients, t-statistics, and p-values (Sutardi & Sugiharsono, 2016). This metric is used to assess the strength and significance of each relationship in the model (Ramadani et al., 2023). The significant results support the hypotheses, indicating that the relationships between the variables are statistically valid. Table 4 summarizes the test results, showing the supported hypotheses as well as the direct and indirect roles of the variables in influencing student learning outcomes.

Table 4. Hypothesis Testing

	Hypothesis	Path Coef	T Statistics	P Values	Decision
H1	DC->LO	0.369	5.477	0.000	Positif and Significant
H2	PT->LO	0.393	6.562	0.000	Positif and Significant
H3	DC->DRM	0.599	11.081	0.000	Positif and Significant
H4	PT->DRM	0.240	4.271	0.000	Positif and Significant
H5	DRM->LO	0131	2.329	0.020	Positif and Significant
H6	DC->DRM->LO	0.078	2.282	0.023	Positif and Significant
H7	PT->DRM->LO	0.031	2.013	0.045	Positif and Significant

The hypothesis testing results presented in Table 4 offer strong validation of the relationships between the constructs in this study-Digital Competence (DC), Psychological Traits (PT), Digital Readiness and Mindfulness (DRM), and Learning Outcomes (LO). The analysis provides convincing evidence that both the direct and indirect pathways between these variables are significant and play an important role in shaping students' academic outcomes in digital learning environments.

Direct Effects

The direct effects of this study highlight the significant roles of Digital Competencies and Psychological Traits in influencing Learning Outcomes, supported by robust theoretical frameworks that provide insights into these relationships.

Digital Competence demonstrated a substantial positive impact on Learning Outcomes, with a path coefficient of 0.369 (t-statistic 5.477, p-value 0.000). This finding aligns with the Technology Acceptance Model (TAM) (Davis, 1989), which asserts that the ease of use and perceived usefulness of digital tools enhance user engagement and performance (Davis, 1989). Furthermore, the Cognitive Load Theory (Sweller, 1988) reinforces this by suggesting that digital competence reduces extraneous cognitive load, allowing students to allocate more mental resources to core learning tasks, thereby improving outcomes (Sweller, 1988). For example, students skilled in utilizing online research tools and collaborative platforms are better positioned to analyze and apply information critically, reflecting Constructivist Learning Theory (Piaget, 1952).

Psychological Traits exhibited an even stronger influence on Learning Outcomes, with a path coefficient of 0.393 (t-statistic 6.562, p-value 0.000). This relationship is supported by Self-Determination Theory (SDT) (Deci & Ryan, 1985), which emphasizes the critical roles of intrinsic motivation and self-regulation in academic success. Students who possess traits such as resilience, emotional regulation, and self-discipline are better prepared to overcome academic challenges, maintain focus, and sustain effort in their studies (Deci & Ryan, 1985).

Digital Competence also had a strong influence on Digital Readiness and Mindfulness, with a path coefficient of 0.599 (t-statistic 11.081, p-value 0.000). According to the Mindfulness-Based Educational Framework (Kabat-Zinn, 2003), digital competence fosters mindfulness by enabling students to manage distractions, prioritize learning tasks, and engage thoughtfully with digital tools. This readiness equips students to establish healthy digital habits, enhancing their focus and overall learning effectiveness (Kabat-Zinn, 2003).

Psychological Traits significantly influenced Digital Readiness and Mindfulness as well, albeit to a lesser extent (path coefficient 0.240, t-statistic 4.271, p-value 0.000). This connection is also

explained by the Mindfulness-Based Educational Framework, which highlights the role of psychological well-being in cultivating awareness and attention in learning environments. Students with strong psychological traits, such as self-efficacy and adaptability, are better able to develop mindfulness practices that support digital engagement, time management, and reflective learning.

Lastly, the effect of Digital Readiness and Mindfulness on Learning Outcomes, with a path coefficient of 0.131 (t-statistic 2.329, p-value 0.020), underscores the importance of preparation and focus in digital learning contexts. Supported by Engagement Theory (Kearsley & Shneiderman, 1998), this finding suggests that students who are mindful and digitally prepared are more likely to stay engaged, avoid distractions, and utilize technology effectively, leading to improved academic performance (Kearsley & Shneiderman, 1998).

Among all examined factors, Psychological Traits demonstrated the strongest direct impact on Learning Outcomes (path coefficient 0.393). This can be attributed to their integral role in fostering self-motivation, emotional stability, and adaptability, which are essential for overcoming challenges and achieving success in complex learning environments. These traits empower students to remain persistent, focused, and adaptable, highlighting their critical contribution to academic excellence.

Indirect Effects

The indirect effects better elucidate the mediating role of Digital Readiness and Mindfulness in the relationship between Digital Competence, Psychological Traits, and Learning Outcomes.

Mediation analysis revealed that Digital Readiness and Mindfulness partially mediated the relationship between Digital Competence and Learning Outcomes (path coefficient 0.078, t-statistic 2.282, p-value 0.023). This finding suggests that while Digital Competence directly enhances Learning Outcomes, its impact is significantly amplified when students are digitally prepared and mindful. According to Cognitive Load Theory (Sweller, 1988), students with advanced digital competence are better at managing extraneous cognitive demands, enabling them to focus more effectively on learning tasks when combined with mindfulness practices (Sweller, 1988). Recent research by Lim et al. (2023) supports this, emphasizing that mindful digital practices allow students to engage deeply with learning materials, thereby improving academic outcomes (Lim et al., 2023).

Similarly, Digital Readiness and Mindfulness mediated the relationship between Psychological Traits and Learning Outcomes (path coefficient 0.031, t-statistic 2.013, p-value 0.045). This finding aligns with the Mindfulness-Based Educational Framework (Kabat-Zinn, 2003), which posits that psychological well-being fosters attention and readiness in learning environments (Kabat-Zinn, 2003). Research by Schonert-Reichl and Roeser (2023) further underscores that mindfulness amplifies the positive effects of psychological traits such as resilience and self-discipline on academic performance, enabling students to better manage time and maintain focus in digital settings (Schonert-Reichl, 2023).

Overall, the results strongly validate that Digital Competence and Psychological Traits are critical drivers of Learning Outcomes, both directly and indirectly, through Digital Readiness and Mindfulness. These findings align with Engagement Theory (Kearsley & Shneiderman, 1998), which highlights that prepared and mindful students are more engaged and effective in their use of digital tools, leading to better academic outcomes (Kearsley & Shneiderman, 1998). Alomari (2023) further supports this by showing that mindfulness enhances attention regulation and working memory, fostering sustained engagement and improved academic performance in digital learning environments (Alomari, 2023).

LIMITATIONS

While these findings offer valuable insights, they are based on cross-sectional data, which limits the ability to infer causality. Future longitudinal studies are needed to explore the temporal dynamics of these relationships. Additionally, the study's focus on a specific educational context may limit generalizability. Replication in diverse settings and with broader populations is necessary to confirm the robustness and applicability of the findings.

CONCLUSION

This study effectively addresses the research objectives by demonstrating how Digital Competence and Psychological Traits influence Learning Outcomes, both directly and indirectly, through Digital Readiness and Mindfulness. The findings validate the synergistic interaction of these factors, underscoring their critical role in enhancing students' academic performance in digital learning environments. These results highlight the importance of integrating technical skills with psychological preparedness to equip students for the complexities of digital education.

The study contributes to the field of education by providing empirical evidence that a holistic approach encompassing digital skills, mindfulness, and psychological resilience yields better academic outcomes. This aligns with calls for educational interventions that go beyond technical training to address mental readiness and emotional well-being. Such interventions are particularly vital in reducing disparities in technology access and supporting students from diverse backgrounds to achieve equitable learning outcomes.

AUTHOR CONTRIBUTIONS

EN and RTM conceptualized the research framework and oversaw data collection. MMF led the statistical analysis and contributed to refining the methodology. MFB and S developed the manuscript draft, while FA provided critical revisions and theoretical insights. All authors collaboratively reviewed and approved the final manuscript.

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