

The Influence of Digital Leadership on Teachers' Technology Integration Self-Efficacy: Evidence from Northern Peninsular Malaysia

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Abstract – This study investigates the direct influence of digital leadership on teachers' technology integration self-efficacy (TTISE) among secondary school teachers in the northern region of Peninsular Malaysia. Grounded in the National Educational Technology Standards for Administrators (NETS.A, 2009) and the Teacher Sense of Efficacy Scale (Tschannen-Moran & Hoy, 2001), the research aims to determine how school leaders' digital competencies shape teachers' confidence in integrating technology for teaching and learning. Using a quantitative design, data were collected from 602 teachers across four northern states—Perlis, Kedah, Penang, and Perak—through a stratified random sampling approach. Structural Equation Modelling using SmartPLS 4.0 was employed to test the hypothesized relationship between digital leadership and TTISE. Results revealed that digital leadership had a significant positive effect on teachers' technology integration self-efficacy ($\beta = 0.254$, $t = 3.882$, $p < 0.001$), indicating that principals who demonstrate strong digital leadership foster greater confidence among teachers in applying technology. The findings underscore the importance of cultivating digital leadership competencies among school administrators to enhance teachers' readiness and motivation toward technology integration. This study contributes empirical evidence to the growing discourse on leadership in digital education transformation and offers implications for professional development programs targeting educational leaders in Malaysia's secondary schools. Future research is recommended to examine additional factors such as mediators and moderators that may influence the relationship between digital leadership and teachers' technology integration self-efficacy.

Keywords – Digital leadership, Technology integration, Self-efficacy, Teacher's technology integration self efficacy.

I. INTRODUCTION

Rapid digitalization is transforming organizations worldwide through advancements in Artificial Intelligence (AI), cloud computing, the Internet of Things (IoT), and data analytics. These technologies are driving the Fourth Industrial Revolution (IR 4.0), which is redefining how organizations operate, communicate, and deliver value across sectors (Schwab, 2024). In this context, leadership now requires the capacity to envision, implement, and sustain digital transformation, extending far beyond traditional administrative skills (Schiuma et al., 2024).

Therefore, Digital leadership (DL) has become essential for organizational adaptability and innovation. It encompasses strategic foresight, digital literacy, socio-technical alignment, and effective governance of digital resources (Karakose et al., 2024). Global analyses emphasize that adopting DL is crucial for institutions to remain relevant and responsive amid rapid technological change (Espina-Romero et al., 2023; Gede & Kawiana, 2023).

The emergence of IR 4.0 also positions education at the forefront of global digital reform. As technological ecosystems evolve and new forms of work and communication emerge, education systems are compelled to reconsider how educators and leaders cultivate the skills, competencies, and mindsets needed to navigate a digitally mediated future (Abdallah et al., 2025). DL in educational institutions is therefore vital for aligning policy with classroom practice. School leaders play a central role in driving pedagogical innovation, integrating new technologies into the curriculum, and fostering continuous learning among teachers and students (Obied, 2025).

In many countries, DL has been identified as the cornerstone of educational innovation and reform. Previous studies indicate that school leaders who exhibit strong DL practices significantly influence teachers' willingness to adopt digital pedagogies and sustain technology-enhanced learning environments (AlAjmi, 2022; Hamzah, 2021; Karakose et al., 2021; Rasdiana et al., 2024). According to the International Society for Technology in Education (ISTE, 2021), effective digital leaders empower educators to transform learning through vision-driven use of technology, collaborative culture, and continuous professional growth. Such leadership ensures that technology integration is purposeful, ethical, and aligned with institutional goals.

The Ministry of Education (MoE) Malaysia's implementation of the Digital Education Policy marks a significant turning point in the development of leaders and teachers who are proficient in digital technology and can promote change in educational institutions (Ministry of Education, 2023). The policy places a strong emphasis on developing leadership skills, creative pedagogy, and digital fluency as essential facilitators of integrating technology into teaching and learning. The introduction of the MoE Strategic Plan (PSKPM) 2024–2030 has further accelerated Malaysia's digital education agenda. Among its five strategic thrusts, Strategic Thrust 2 specifically focuses on strengthening digital education by empowering teachers and educational leaders to cultivate digitally competent students (Ministry of Education, 2024).

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These reforms highlight a more future-oriented approach to curriculum and pedagogy, reflecting the need for schools to align instructional practices with digital-age competencies. Within this evolving landscape, principals play a critical role as digital leaders, shaping a culture that supports innovation, collaboration, and technology-enabled teaching (Sunu, 2022). At the same time, teachers' technology integration self-efficacy (TTISE) in using digital tools are crucial for realising the aspirations of Malaysia's digital education transformation (Y. A. Bakar et al., 2024; Rahman & Hamid, 2025). A further challenge arises from the rapidly evolving technological landscape, which creates a shifting target for teachers' self-efficacy (Saienko et al., 2020). As new tools emerge and existing ones' advance, teachers must continuously update their skills and pedagogical approaches. Therefore, when school leaders' model effective digital practices and provide sustained support, teachers are better equipped to implement technology-enhanced pedagogies that foster engagement, creativity, and lifelong learning.

II. PROBLEM STATEMENT

Despite continuous policy reforms and curriculum innovations, many Malaysian teachers remain hesitant to integrate technology meaningfully into their teaching practice (Ministry of Education, 2023b). Previous studies have highlighted that this reluctance is often attributed to limited technological self-efficacy and insufficient leadership support (Muniandy & Kamsin, 2024; Fazzlijan, 2020; Mohd Norakmar Omar et al., 2019). Teachers tend to feel less confident in applying digital tools to support student-centred learning, differentiate instruction, or assess performance through technology (Subramaniam et al., 2024a). This challenge is critical, as low levels of self-efficacy have been shown to hinder teachers' ability to adapt technological resources effectively, thereby weakening the depth and quality of technology integration in classroom instruction (Skaalvik & Skaalvik, 2014).

Furthermore, low technological self-efficacy among teachers is associated with broader pedagogical issues, including difficulties in delivering effective learning experiences, reduced innovation in instructional design, and limited capacity to engage students through digital approaches (Zee & Koomen, 2016; Zimu, 2024). As a result, Malaysia continues to experience gaps between infrastructural readiness and actual pedagogical application of technology, despite significant national investments and progressive digital education agendas (Siong & Bity Salwana, 2024). These persistent disparities highlight the need to understand the factors that influence TTISE, particularly the role of school leadership in shaping teachers' readiness, confidence, and motivation to adopt digital pedagogies.

While existing literature establishes a theoretical link between leadership practices and TTISE, empirical research in the Malaysian context remains limited. Most prior studies have explored teachers' technology readiness or digital competence, yet few have examined how principals' DL behaviours shape teachers' confidence to integrate technology effectively (Fahmi et al., 2024; Mohd

Norakmar Omar et al., 2020; Roslan, 2024). Addressing this research gap is crucial, as strong DL can catalyse transforming school culture, promote innovation, and sustain digital pedagogical practices. Therefore, this study seeks to investigate the influence of DL on TTISE in Northern Peninsular Malaysia, offering empirical insights into how leadership actions can empower teachers and enhance digital transformation in schools.

III. LITERATURE REVIEW

Digital leadership

In this study, DL in education is defined as the capacity of school leaders to integrate and manage technology strategically to shape a digital learning culture and drive effective transformation in both teaching-learning and school administration in line with the National Educational Technology Standards for Administrators (NETS.A)(ISTE, 2009). NETS.A specifies five core dimensions: visionary leadership, which involves articulating and communicating a shared, technology-infused vision; digital-age learning culture, which focuses on creating and sustaining learner-centred, technology-rich environments; excellence in professional practice, which concerns modelling and supporting ongoing technology-enabled professional learning; systemic improvement, which refers to using digital tools and data for continuous organisational improvement; and digital citizenship, which emphasises ethical, responsible, and safe use of technology within the school community (ISTE, 2021). These five dimensions together capture principals' ability to plan, implement, and monitor digital initiatives, and they therefore serve as the basis for measuring principals' DL in this research, consistent with prior empirical work that operationalises DL using the NETS.A standards (Hamzah, 2021; Sanmugam et al., 2023).

Recent research in Malaysia and abroad consistently affirms that strong DL is essential for advancing teachers' technology integration and accelerating school-wide digital transformation. Although Malaysian principals often demonstrate high levels of DL, its influence on classroom practice remains moderate, signalling a persistent gap between leadership intent and pedagogical implementation (Hamzah, 2021; Okunlola, 2025). Studies also show that key NETS.A dimensions particularly digital-age learning culture and digital citizenship significantly shape teachers' digital competence and confidence (A'mar & Eleyan, 2022). International evidence echoes this pattern, with findings from Nigeria, and other contexts demonstrating that NETS.A-aligned DL strongly predicts teachers' technology uptake and readiness for emerging tools such as AI (AlAjmi, 2022). Collectively, these studies underscore DL as a decisive lever for strengthening teachers' self-efficacy and driving effective digital transformation in schools.

Teacher's technology integration self-efficacy

TTISE is conceptualised in this study based on the Teachers' Sense of Efficacy Scale (TSES) developed by Tschannen-Moran and Hoy (2001), which defines teacher self-efficacy through three domains: student engagement, instructional strategies, and classroom management. When applied to a digital context, TTISE represents teachers' confidence in their ability to plan and implement technology integration effectively in their instructional practice (Tschannen-Moran & Hoy, 2001).

Recent Malaysian research demonstrates that TTISE is one of the meaningful predictors of technology integration in the classroom. Teachers with stronger self-efficacy beliefs are more likely to adopt innovative digital pedagogies, while those with low self-efficacy tend to limit their use of technology or rely on surface-level applications (Fazzlijan, 2020; Hamzah, 2021; Mohd Norakmar Omar et al., 2019; Rahman & Hamid, 2025). Studies also highlight that mastery experience, peer modelling, and social persuasion are key determinants of TTISE, underscoring the importance of fostering self-efficacy (Subramaniam et al., 2024b). International scholarship echoes these trends, with evidence showing that higher TTISE correlates with effective digital instructional strategies, and better adaptation to technology-intensive teaching environments (Gomez et al., 2020; Njiku et al., 2022). These findings reinforce TTISE as an essential construct for understanding teachers' readiness for digital pedagogy.

Relationship Between DL and TTISE

The rising number of studies demonstrates that DL and TTISE are highly connected. Teachers' confidence in their ability to utilise technology effectively is increased when principals model the use of digital tools, encourage innovation, and express a clear digital vision (Fazzlijan, 2020; Hamzah, 2021). According to Malaysian research, digital-age learning culture, professional learning support, and systemic improvement strategies all have a substantial impact on teachers' confidence and willingness to implement digital pedagogy (Y. A. Bakar et al., 2024; Sanmugam et al., 2023). This is supported by studies from throughout the world, which shows that effective DL promotes TTISE by making resources more accessible, fostering collaborative learning environments, and offering instructional and emotional support (Paunil, 2024; Rasdiana et al., 2024). Figure 1 shows the conceptual relationship between DL and TTISE.

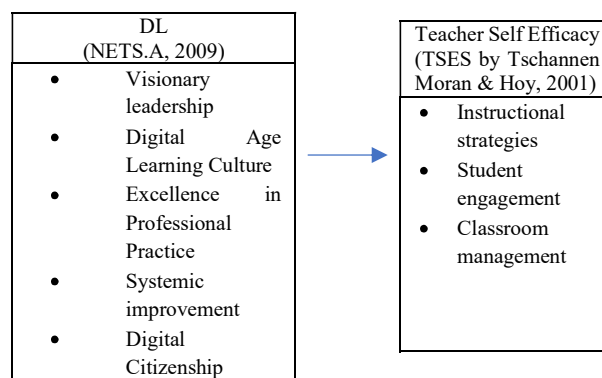


Figure 1. The Relationship Between Digital Leadership and Teacher's Self-Efficacy

In Figure 1, DL, represented through five key elements which are visionary leadership, digital age learning culture, excellence in professional practice, systemic improvement, and digital citizenship (ISTE, 2021). All these elements reflect the school leader's role in shaping a technology-enabled and values-driven learning environment. These dimensions emphasise leaders' responsibility in setting clear digital visions, fostering innovative pedagogical cultures, modelling effective digital practices, ensuring continuous technological improvement, and cultivating ethical technology use within the school (Rahman & Hamid, 2025).

These leadership practices are proposed to influence and enhance teacher self-efficacy, which encompasses teachers' beliefs in their capability to carry out essential teaching tasks. According to the TSES model, teacher self-efficacy consists of three domains: instructional strategies, student engagement, and classroom management (Tschannen-Moran & Hoy, 2001). When leaders demonstrate strong DL, teachers are more likely to feel supported with resources, guided through meaningful professional development, empowered to use technology effectively, and confident in managing digital-rich learning environments (Ismail et al., 2021).

IV. METHOD

This study employed a quantitative survey design to examine the influence of DL on TTISE among secondary school teachers in Northern Peninsular Malaysia. A survey method was selected as it enables the collection of large-scale empirical data and facilitates statistical analysis appropriate for predictive modelling and structural equation analysis (Creswell, 2014).

The population of this study consisted of 25,181 teachers serving in National Secondary Schools across four northern states: Perlis, Kedah, Penang, and Perak. Based on the Krejcie and Morgan (1970), sample size determination table, a minimum of 378 respondents was required. However, a total of 602 responses were collected.

A multi-level sampling approach was employed to ensure adequate representation across states, districts, and schools in Northern Peninsular Malaysia. Proportionate

stratified random sampling was first conducted to select teacher groups from each state and district. This technique ensures that each subgroup is represented in the same proportion as it exists in the population, thereby increasing sample accuracy and reducing sampling error (Fraenkel & Wallen, 2009). Following this, simple random sampling was used to select the participating schools, giving each school an equal and independent chance of being chosen from the population (Chua, 2012; Cohen, 2011). Within each selected school, systematic random sampling was applied to determine teacher respondents, a method commonly used when all teachers are listed on the school's staff registry, allowing for an orderly and unbiased selection process (Mertler & Charles, 2008). The use of these combined sampling techniques enhanced the representativeness of the sample and minimised potential sampling bias.

DL was measured using an instrument adapted from the Principal Technology Leadership Assessment (PTLA) developed by ISTE (2009), based on the original NETS.A. For this study, the instrument was contextualised to the Malaysian educational setting by incorporating elements from the High-Impact Malaysian School Leadership Competency Standards embedded in the School Leaders' Competency Instrument (KOMPAS) developed by the Aminuddin Baki Institute (Leong et al., 2016). The final instrument consisted of 32 items across five NETS.A dimensions and was rated on a five-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Agree, 4 = Agree, 5 = Strongly Agree.

Meanwhile, TTISE was assessed using the Teachers' Sense of Efficacy Scale (TSES) developed by Tschannen-Moran and Hoy (2001). The instrument comprised 24 items across three constructs, also rated on a five-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Agree, 4 = Agree, 5 = Strongly Agree.

Content validity was established through expert evaluation. Five appointed subject-matter experts assessed the relevance and clarity of the items using the Content Validity Index (CVI). According to Polit et al., (2007), higher CVI values indicate stronger agreement among experts. The CVI values obtained were 0.99 for the DL instrument and 0.98 for the TTISE instrument, indicating excellent content validity.

Face validity was conducted with three secondary school teachers representing diverse backgrounds. They reviewed the instruments for clarity, font type and size, layout, and language appropriateness.

A pilot study was carried out to determine the instruments' reliability. The Cronbach's Alpha for the 32-item DL instrument was 0.98, while the 24-item TTISE instrument recorded a reliability coefficient of 0.97, indicating excellent internal consistency.

Data collected through the survey were analysed using IBM Statistical Package for the Social Sciences (SPSS) version 30.0. Preliminary analyses including data screening, treatment of missing values, and assessment of normality were first conducted in SPSS and Microsoft Excel to ensure the integrity of the dataset. The cleaned dataset was then exported to SmartPLS 4.0 for Partial Least Squares Structural Equation Modelling (PLS-SEM),

which was employed to evaluate the measurement model, test the structural relationships, and validate the proposed hypotheses.

Before executing the multivariate procedures in SmartPLS, several methodological diagnostic checks were performed to confirm that the data met the minimum analytical requirements. These checks included assessments of normality and linearity, inspection of multicollinearity and the detection of multivariate outliers through the Mahalanobis distance. This evaluation is crucial, as violations of these assumptions can compromise the accuracy of statistical results and potentially lead to invalid or misleading conclusions (Meyers et al., 2016). These procedures ensured that the dataset adhered to the technical assumptions necessary for producing robust and credible PLS-SEM results.

V. FINDINGS

This section presents the empirical findings of the study based on data collected from 602 secondary school teachers across Northern Peninsular Malaysia. The analysis focuses on two main constructs which are Digital leadership, measured through five dimensions adapted from the NETS.A framework, and TTISE, measured across three dimensions based on Tschannen-Moran and Hoy's (2001) model. Descriptive statistics were first examined to understand the overall levels and patterns of both constructs among respondents. Subsequently, structural equation modelling (PLS-SEM) was employed to assess the hypothesised relationship between DL and TTISE. Hair Jr et al., (2021) emphasise that descriptive statistics serve as a foundational diagnostic stage in SEM, offering critical context for interpreting subsequent measurement and structural model results. The findings presented in the following subsections provide a comprehensive overview of the constructs and offer evidence supporting the study's conceptual framework.

As part of the preliminary data screening process, 26 straight-lining cases were removed, resulting in a final dataset of 576 valid responses for further analysis. Subsequently, a Mahalanobis distance analysis was conducted to identify potential multivariate outliers. A total of 11 cases were identified. However, these observations were retained because their removal produced less than a 10% change in the R² values, indicating that they did not meaningfully affect the model's explanatory power. In line with established methodological guidelines, outliers may be preserved when their exclusion does not substantially improve model explanatory power or alter the structural relationships in a meaningful way (Sarstedt et al., 2021). Thus, retaining the 11 cases was considered appropriate and did not compromise the robustness of the subsequent analyses.

The descriptive results for teachers' perceptions of principals' DL were consistently high across all five dimensions measured using the NETS.A-based instrument. As presented in Table 1, the mean scores for these dimensions ranged from 4.07 to 4.18, indicating strong agreement among teachers that their principals actively demonstrate DL practices in both day-to-day

school management and instructional support. These results suggest that DL behaviours are well established within the school environment and are positively recognised by teachers.

TABLE I: DESCRIPTIVE ANALYSIS FOR DIGITAL LEADERSHIP

Construct	N	Mean	SD	Level
Digital Leadership	576	4.11	0.55	High
Visionary Leadership	576	4.18	0.63	High
Digital Age Learning Culture	576	4.13	0.60	High
Excellence in Professional Practice	576	4.09	0.63	High
Systemic Improvement	576	4.07	0.62	High
Digital Citizenship	576	4.11	0.59	High

The descriptive analysis in Table 1 shows that teachers perceived principals' DL to be at a high level overall. The composite mean score for DL is 4.11 (SD = 0.55), indicating strong implementation of DL practices across the sampled schools. Among the five dimensions, Visionary Leadership recorded the highest mean (M = 4.18, SD = 0.63), reflecting principals' strong ability to articulate and drive a clear digital vision that aligns with school improvement and instructional innovation. This is followed by Digital-Age Learning Culture (M = 4.13, SD = 0.60), suggesting that principals actively encourage the use of technology to enrich pedagogical practices and promote collaboration among teachers. Similarly, Digital Citizenship (M = 4.11, SD = 0.59) was rated highly, indicating principals' emphasis on ethical and safe use of technology in school settings. The dimensions of Excellence in Professional Practice (M = 4.09, SD = 0.63) and Systemic Improvement (M = 4.07, SD = 0.62) also demonstrated high mean values, highlighting principals' ongoing support for teacher professional development and continuous enhancement of digital infrastructure and processes. Overall, these findings suggest that DL practices are strongly embedded across secondary schools in Northern Peninsular Malaysia.

Meanwhile, the descriptive analysis for TTISE as in Table 2, reveals that teachers in Northern Peninsular Malaysia reported a high level of technology integration self-efficacy, with an overall mean score of 4.25 (SD = 0.46). This indicates strong confidence among teachers in their ability to plan, implement, and manage technology-enhanced teaching and learning.

TABLE II: DESCRIPTIVE ANALYSIS FOR TTISE

Construct	N	Mean	SD	Level
TTISE	576	4.25	0.46	4.25
Instructional Strategies	576	4.04	0.52	High
Classroom Management	576	3.85	0.61	Moderate-High
Student Engagement	576	4.00	0.55	High

Based on Table 2, at the dimensional level, Instructional Strategies is recorded as having the highest mean (M = 4.04, SD = 0.52), suggesting that teachers feel capable of selecting and applying digital tools to support effective instructional practices. Student Engagement also demonstrated a high mean (M = 4.00, SD = 0.55), indicating that teachers believe they can use technology to stimulate student interest, promote active participation, and support diverse learning needs. Meanwhile, Classroom Management recorded a slightly lower, though still moderate-to-high score (M = 3.85, SD = 0.61), showing that some teachers may feel less assured in managing digitally supported learning environments, including handling disruptions or maintaining student focus when using technology. Overall, these findings suggest that while teachers generally possess strong beliefs in their ability to integrate technology into pedagogy, targeted support may still be needed to strengthen their confidence in managing technology-rich classrooms.

Next, some procedures been done to test the data before run the structural model. First, the researcher done the normality test using Skewness and kurtosis method. According to Sarstedt et al., (2021), assessing the normality of the data is recommended even when using the PLS-SEM approach, as it helps ensure the quality and reliability of the analysis. Researchers are also encouraged to examine the levels of skewness and kurtosis to determine whether the data follow a normal distribution. Table 3 shows the result of Skewness and Kurtosis.

TABLE III: SKEWNESS AND KURTOSIS VALUE

Construct	Skewness	Kurtosis
DL	- 0.810	0.753
TTISE	- 0.448	0.425

Based on Table 3, the skewness, and kurtosis values indicate that both constructs deviate slightly from a perfectly normal distribution. DL shows a skewness of -0.810 and kurtosis of 0.753, suggesting a moderately left-skewed distribution with a slightly peaked shape. Meanwhile, TTISE records a skewness of -0.448 and kurtosis of 0.425, indicating a mild negative skew and a distribution that is close to normal. According to Sarstedt et al., (2021), such levels of skewness and kurtosis are generally acceptable in behavioural research, particularly when employing PLS-SEM, which is robust to non-normal data. These results therefore do not pose concerns for subsequent multivariate analysis.

The next multivariate assumption pertains to the existence of a linear relationship between each independent variable and the dependent variable. In this study, the linearity assumption was evaluated by examining the scatter plot of DL against TTISE. Visual inspection revealed a clear positive linear pattern, indicating that higher levels of DL were consistently associated with higher levels of TTISE. The distribution of data points aligned closely with the fitted regression line and displayed no noticeable curvature or deviation from linearity. This pattern provides strong evidence that the linearity assumption has been met, thereby supporting the

appropriateness of proceeding with subsequent multivariate analyses (Sarstedt et al., 2021).

Then, a full collinearity test was conducted to determine whether any construct exhibited a Variance Inflation Factor (VIF) value equal to or less than 5 (Kock & Lynn, 2012). The Tolerance and VIF analyses were performed using the regression output generated through SPSS version 30, as presented in Table 4.

TABLE IV: VARIANCE INFLATION FACTOR (VIF)

Model	B	t	Sig.	Tolerance	VIF
Constant	1.186	7.728	<.001		
DL	.270	6.836	<.001	.581	1.720

Based on Table 4, the tolerance values for both variables were 0.581, which is well above the threshold of 0.10, while the VIF values were 1.720, far below the recommended cut-off of 3.3. According to Hair et al., (2019) and Pallant (2020), tolerance values greater than 0.10 and VIF values less than 3.3 indicate a low level of multicollinearity, thus confirming that the assumption of no multicollinearity has been satisfactorily met in this study.

After completing all assumption and violation checks, the structural model was subsequently assessed to determine the predictive influence of DL on TTISE. The structural relationships were evaluated using the bootstrapping procedure in SmartPLS, employing 5,000 resamples as recommended by Sarstedt et al., (2021). The results presented in Table 5 indicate that DL exerts a positive and statistically significant effect on TTISE, with a path coefficient of $\beta = 0.254$. This relationship yielded a t-value of 3.882 and a p-value of 0.000, demonstrating significance at the 0.001 level. These findings confirm that higher levels of DL are associated with increased TTISE.

To evaluate the model's explanatory power, the R^2 value for EGMT was examined. The model recorded an $R^2 = 0.432$, indicating that 43.2% of the variance TTISE is explained by DL alone. According to Sarstedt et al., (2021), this represents a moderate level of predictive accuracy, especially for a model with a single exogenous construct. Meanwhile, the effect size (f^2) for the influence of DL on TTISE was 0.059, demonstrating a statistically significant but small effect size. Although the magnitude is small, the result indicates that DL contributes meaningfully to improvements in TTISE.

TABLE V: PATH COEFFICIENTS, EFFECT SIZES, AND EXPLAINED VARIANCE FOR THE DIGITAL LEADERSHIP-TTISE STRUCTURAL MODEL

Relationship	β	t-value	p-value	Effect size (f^2)	R^2
DL → TTISE	0.254	3.882	0.000	0.059	0.432

Overall, these results in Table 5, indicate that DL meaningfully enhances teachers' confidence in integrating technology, confirming its role as an important driver of TTISE in secondary schools. Although the effect size is

small, the significant path coefficient and moderate R^2 value suggest that principals' DL practices such as providing direction, modelling technology use, and supporting digital initiatives contribute to strengthening TTISE.

VI. DISCUSSION

The findings of this study provide empirical evidence that DL significantly influences TTISE in secondary schools across Northern Peninsular Malaysia. The positive and significant path coefficient ($\beta = 0.254$, $p < 0.001$) indicates that principals who demonstrate strong DL are more likely to cultivate teachers' confidence in planning, managing, and implementing technology-supported instruction. This supports previous studies that highlight the pivotal role of leadership in shaping teachers' digital competencies and motivation to use educational technologies (Hamzah, 2021; Mohd Norakmar Omar et al., 2019; Rahman & Hamid, 2025). The high mean scores across all dimensions of DL further reinforce that when school leaders articulate a clear digital vision, create technology-rich learning cultures, and model ethical and effective technology use, teachers tend to internalise these behaviours and feel more capable of integrating technology into their teaching.

The moderate R^2 value (0.432) suggests that DL accounts for a substantial proportion of the variance in TTISE, particularly for a model with a single predictor. This finding aligns with earlier Malaysian evidence, such as Yoehana A. Bakar et al., (2024) and Syamimi and Aida Hanim (2025), who identified a significant but weak positive correlation between principals' DL practices and teachers' self-efficacy ($r = 0.235$, $p < 0.01$). Taken together, these results reinforce the notion that while principals typically exhibit strong DL competencies, the degree to which these practices translate into effective classroom-level technology integration depends largely on how leadership strategies are enacted, supported, and sustained within the school environment (Fazzlijan, 2020; Rasdiana et al., 2024).

The small but significant effect size ($f^2 = 0.059$) also suggests that while DL is an important driver, TTISE is multidimensional and may be influenced by other enabling factors such as access to digital infrastructure, quality professional development, peer collaboration, and school culture. These additional factors have been highlighted in both local and global literature as essential components of effective technology integration ecosystems (N. S. A. Bakar et al., 2018; Barton & Dexter, 2020; Njiku et al., 2020; Rosalina et al., 2024). This also suggests the supporting factors such as ongoing professional development, adequate digital resources, and a supportive school culture, may further enhance the strength of this relationship in future models (Y. A. Bakar et al., 2024).

Overall, the findings reinforce the argument that is not merely an administrative function, but a strategic and instructional catalyst that directly enhances teachers' confidence and capability in digital pedagogy. By strengthening leadership practices particularly in visionary planning, digital-age learning culture, and systemic

improvement, schools can create more supportive environments that enable teachers to integrate technology meaningfully and sustainably. The results align well with Malaysia's ongoing educational digitalisation agenda and underscore the need for holistic, multi-level strategies that empower both school leaders and teachers to navigate the demands of emerging digital learning environments (Ministry of Education., 2024; Nordin et al., 2023).

VII. CONCLUSION

This study provides empirical evidence that DL significantly influences TTISE in secondary schools across Northern Peninsular Malaysia. The positive path coefficient demonstrates that principals who articulate a clear digital direction, model effective technology use, and provide structured support can enhance teachers' confidence in integrating digital tools into their instructional practice. The moderate R^2 value (0.432) indicates that DL is an important predictor of TTISE, although additional factors also play a role. Overall, the findings reinforce the importance of strengthening school leadership capacity as a key strategy for supporting Malaysia's digital education agenda, particularly in preparation for the implementation of the Digital Education Policy and MoE's Strategic Plan 2024-2030.

Several limitations should be acknowledged in this study. First, the use of a cross-sectional survey design restricts the ability to draw causal conclusions about the relationship between DL and TTISE. Second, the study focused solely on secondary school teachers from Northern Peninsular Malaysia, which may limit the generalisability of the findings to other regions or school types. Third, the model included only one predictor, meaning that other relevant variables influencing TTISE were not examined. Finally, data were based on self-reported perceptions, which may be influenced by social desirability bias.

Future research could address these limitations by adopting a longitudinal or mixed-methods design to capture changes in TTISE over time and gain deeper insights into teachers' lived experiences with digital integration. Expanding the sample to include primary schools, rural schools, or additional Malaysian regions would improve generalisability. Researchers may also consider incorporating additional predictors such as digital infrastructure quality, professional development, teacher professional collaboration, digital competence, or school culture to develop a more comprehensive model. Finally, future studies could explore emerging constructs such as AI readiness or technology acceptance to better understand the evolving dynamics of digital education in Malaysia. Also, it is recommended to examine additional factors such as mediators and moderators that may influence the relationship between DL and TTISE.

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