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Exploring the Relationship between Technology Adaptation and Digital Innovation with Leadership Strategies as a Mediator for Digital Leadership in the Underprivileged School

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Abstract

This study aims to understand the relationship between technology adaptation, digital innovation, leadership strategy, and digital leadership in the context of digital transformation. The study involved 175 headmasters from schools in Sabah, using the PLS-SEM (Partial Least Squares Structural Equation Modeling) approach through Smart PLS 4 software. This approach was chosen because it is suitable for models with latent variables and moderate sample sizes. Data analysis involves three main steps: (a) Reliability and Validity Tests to ensure internal validity of constructs, (b) Measurement Model Analysis to examine the relationship between leadership strategies, emotional intelligence, and digital leadership, and (c) Relationship Validation Tests to validate significant relationships through path coefficients and p-values.The findings show that leadership strategy plays an important role as an

intermediary element between the adaptation of technology and digital innovation to digital leadership. While technology and innovation provide an important foundation, their impact depends on a carefully planned strategy. The significant relationship between leadership strategy and digital leadership shows that smart leaders leveraging strategies can drive adoption of technology and accelerate organizational culture transformation. However, the direct link between technology adoption and digital leadership is insignificant, suggesting the need for work culture change and leadership capacity building. This study makes an important contribution to the literature on digital transformation, emphasizing the need for a holistic approach that combines modern technology, innovative strategies, and a progressive organizational culture. The decision also provides guidance for organizational leaders to increase the effectiveness of digital transformation through appropriate leadership strategies and strengthening leadership capacity.

Keywords: Technology Adaptation, Digital Innovation, Digital Transformation, Digital Leadership, Underprivileged School

Introduction

Organizational agility, which refers to an institution's ability to respond quickly and adaptively to change, is gaining traction in the context of digital transformation. In education, this concept is critical because the ability of schools to adapt to digital technologies can improve the efficiency of teaching and learning. Research shows that strategic agility is closely related to the success of digital transformation, as it facilitates the adoption of new technologies as well as supports the development of more efficient operating models (Octavia & Alamsjah, 2023).

Digital leadership, on the other hand, demands the adoption of innovative and flexible leadership styles to guide schools towards achieving a vision of excellence in education. School leaders need to be agents of change, drive the adoption of technology among teachers, and create an organizational culture that supports educational innovation. Studies show that transformational and multidimensional leadership plays a major role in guiding digital change, especially in increasing teachers' acceptance of new technologies such as DELIMa (Aminah, 2010; Raja Noor Alina & Mastura, 2018; Luqman Hadi, 2021).

Taking into account the strategic role of leadership and the importance of agility in digital transformation, this study aims to explore how leadership strategies can be a mediator in connecting organizational agility with digital leadership success in underserved schools. This study is not only relevant for understanding the relationship between these factors but also provides practical guidance for improving the efficiency and effectiveness of digital leadership in the education sector.

Background Studies

Digital transformation in education is increasingly gaining attention in the era of globalization and the Industrial Revolution 4.0. Schools as educational institutions need to be prepared for these changes by introducing innovative approaches in teaching, learning, and management. However, these changes require organizational agility that allows schools to respond quickly and strategically to new challenges and opportunities (Octavia & Alamsjah, 2023; Aminah, 2010).

Organizational agility not only involves the ability to adapt, but also reflects the capacity to innovate work processes and methods. In the context of schools, this agility is essential to ensure the effective application of digital technologies, including the use of learning platforms such as DELIMa, which has become a key pillar in digital education in Malaysia (Raja Noor Alina & Mastura, 2018; Luqman Hadi, 2021). However, the application of this technology often relies on the leadership style of the principal or headmaster as an agent of change.

Recent studies show that strategic leadership plays a crucial role in connecting organizational agility with digital transformation success. Transformational and multidimensional leadership, which encompasses structural, symbolic, and human resource aspects, has proven effective in driving technological innovation and organizational culture change in education (Syntax Admiration, 2023; Bolman & Deal, 2003). In this context, leadership strategy acts as a mediator that connects the need for organizational agility with the ability to achieve digital transformation goals.

Therefore, this study aims to understand how organizational agility, leadership strategies, and digital leadership can interact with each other to improve school management efficiency in the digital era. This research is relevant to provide guidance to school leaders in devising appropriate strategies to ensure that digital transformation can be achieved effectively and sustainably.

Literature Review

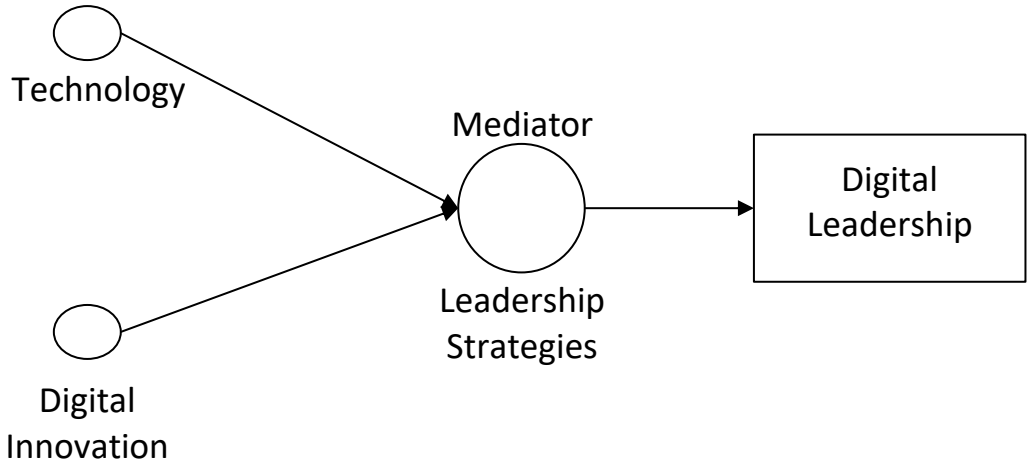
Organizational agility reflects an institution's ability to respond proactively to change. In education, technology adaptation is an important element to ensure the effectiveness of operations in the digital era. Studies show that agile organizations are more likely to adopt new technologies rapidly, which in turn improves teaching and learning efficiency (Octavia & Alamsjah, 2023).

Platforms like DELIMa in Malaysia are an example of the adoption of technology that requires the support of an agile organizational culture. In this case, schools that successfully implemented DELIMa demonstrated the ability to foster change through intensive teacher training and the provision of adequate infrastructure (Raja Noor Alina & Mastura, 2018). In addition, digital innovation also plays an important role. The study found that schools that integrate technologies such as data analytics and virtual learning can improve teaching effectiveness, despite challenges such as infrastructure constraints and work culture barriers (Aminah, 2010; Syntax Admiration, 2023).

Leadership strategies act as a link between organizational agility and the effectiveness of digital transformation. Strategic leadership helps formulate a vision, organize resources, and encourage collaboration within the organization. Bolman and Deal (2003) introduced a multidimensional leadership model, which integrates structural, symbolic, human resources, and political aspects. This model is relevant in leading change in schools, especially in overcoming obstacles to new technologies. Smart strategic leadership is also able to create innovation strategies that are in line with organizational needs, as well as increase teachers' acceptance of technological change (Journal of Leadership in Education, 2024).

Digital leadership is essential in the era of technological transformation. Successful digital leaders must possess the skills to integrate technology into organizational processes while ensuring that a culture of innovation is strengthened. Luqman Hadi (2021) emphasized that school leaders need to be positive models of technology to motivate teachers. In addition, transformational leadership that drives organizational culture change is a determining factor in the application of digital technology (Aminah, 2010).

Through the integration of technology adaptation, digital innovation, strategic leadership strategies, and digital leadership approaches, educational organizations can drive sustainable and effective change. These studies provide a strong theoretical framework to understand how these elements interact with each other in the success of a school's digital transformation.



Methodology

The research methodology used in this study included data acquisition through questionnaires distributed to headmasters in disadvantaged schools, with responses submitted online via a link to the Google Form application. The questionnaire data has been collected and will undergo analysis through descriptive statistical methods and inference statistics to determine any relationship related to the variables of Agility, Leadership Strategies and Digital Leadership. These studies used quantitative research techniques and required the collection of data from a complete sample. Descriptive research facilitates the measurement of reliability and the examination of relationships between variables (Fulk 2023). Data analysis will be conducted using the Statistical Package for Social Science software (SPSS) (Uluyol et al., 2022). The Likert scale will be implemented to analyze closed questions (Ibrahim 2018), while event and inference statistics will be used to interpret research questions at a significance threshold of $p < 0.05$ (De Klerck et al., 2014).

Study Design

This study uses a quantitative approach with a correlation descriptive design to explore the relationship between leadership strategies and emotional intelligence on digital leadership. This study focused on headmasters in restrictive schools in the state of Sabah. The location of the study was chosen because of the unique challenges faced by these schools, including technological constraints, challenging terrain, and limited access to digital facilities.

Sampling

The study sample consisted of 175 headmasters serving in recumbent schools in Sabah. Stratified sampling techniques are used to ensure that each rural zone in Sabah is proportionally represented. Sample selection criteria included a leadership strategy of at least five years and involvement in the school leadership process involving digital elements, such as the use of learning management systems or digital technology in administration.

Data Collection Instruments

Data were collected using questionnaires developed based on previous studies. The questionnaire covers four main sections:

a. **Leadership Strategy**: Assesses the leader's approach to designing, implementing, and evaluating digitalization strategies in schools. This scale is adapted from Bass & Evosio's Transformational Leadership Model (1994), which emphasizes strategic vision, inspirational influence, and motivation for change.
b. **Technology Adaptation**: Assesses the leader's ability to identify, adapt, and integrate new technologies into organizational practices. This scale is adapted from the Rogers Model (1995), which emphasizes elements such as technological readiness, acceptance of change, and digital literacy.
c. **Digital Innovation**: Assesses the ability of leaders to promote a culture of innovation through the use of digital technology, including sparking new ideas, solving complex problems with innovative approaches, and encouraging creativity among the school community. This scale is adapted from the Oslo Manual (2018), which emphasizes innovation in products, processes, and systems.
d. **Digital Leadership**: Assesses the digital competencies of leaders in designing and executing digital strategies that align with the organization's vision. The scale is adapted from ISTE's Digital Leadership Model (2019), with a focus on aligning technology with strategic objectives, digital resource management, and strengthening digital collaboration.

Data Analysis Methods

The data analysis was carried out using the PLS-SEM (Partial Least Squares Structural Equation Modeling) approach through Smart PLS 4 software. This method was chosen because it is suitable for models with latent variables and a moderate sample size.

The analysis process involves:

a. Reliability and Validity Test: Checking the Cronbach's Alpha (CA), Composite Reliability (CR) and Average Variance Extracted (AVE) values to ensure the internal validity of the construct.
b. Measurement Model Analysis: Tests the relationship between leadership strategy, emotional intelligence, and digital leadership.
c Relationship Validation Test: Uses Path Coefficients and p-values to validate significant relationships.

The results of this analysis will be used to determine the direct and indirect influence of leadership strategies and emotional intelligence on the effectiveness of digital leadership in underserved schools. The findings of the study are expected to make a meaningful contribution to the development of policy and leadership training programmes in Malaysia.

Findings

Table 3.1

Reliability and Validity Test: Checking Cronbach's Alpha (CA), Composite Reliability (CR) and Average Variance Extracted (AVE) values

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Digital Innovation	0.956	0.959	0.963	0.765
Digital Leadership	0.874	0.876	0.903	0.572
Leadership Strategies	0.93	0.938	0.943	0.675
Technology Adaptation	0.956	0.959	0.963	0.763

Table 3.1 shows the results of the reliability and validity analysis of the main construct, evaluating Composite Reliability (CR), Average Variance Extracted (AVE), and Cronbach's Alpha. The Digital Innovation and Technology Adaptation construct showed the highest performance in all metrics. The CR values (rho_a = 0.959, rho_c = 0.963) respectively reflect a very high level of reliability. AVE values of 0.765 and 0.763, respectively, indicate that most of the variance in the construct is explained by its item. Furthermore, Cronbach's Alpha value for both constructs is 0.956, signifying a strong and stable internal consistency.

Leadership Strategies also recorded good reliability with a CR (rho_a = 0.938, rho_c = 0.943) and an AVE value of 0.675, above the minimum threshold of 0.5. This indicates sufficient validity of discrimination as well as good internal consistency, as supported by Cronbach's Alpha value of 0.93. However, Digital Leadership performs more modestly. The CR value (rho_a = 0.876, rho_c = 0.903) is still within the acceptable range, but the AVE value of 0.572 is lower than other constructs. Although this value is still above the minimum threshold of 0.5, it indicates that some of the variance in this construct may be influenced by external factors. Cronbach's Alpha score of 0.874 for Digital Leadership is also lower than other constructs but still shows satisfactory internal reliability.

Overall, all constructs achieved minimum standards for reliability and validity, with Digital Innovation and Technology Adaptation recording the strongest performance. However, the Digital Leadership construct may require further reinforcement through item enhancements to improve clarity and relationship with its construct.

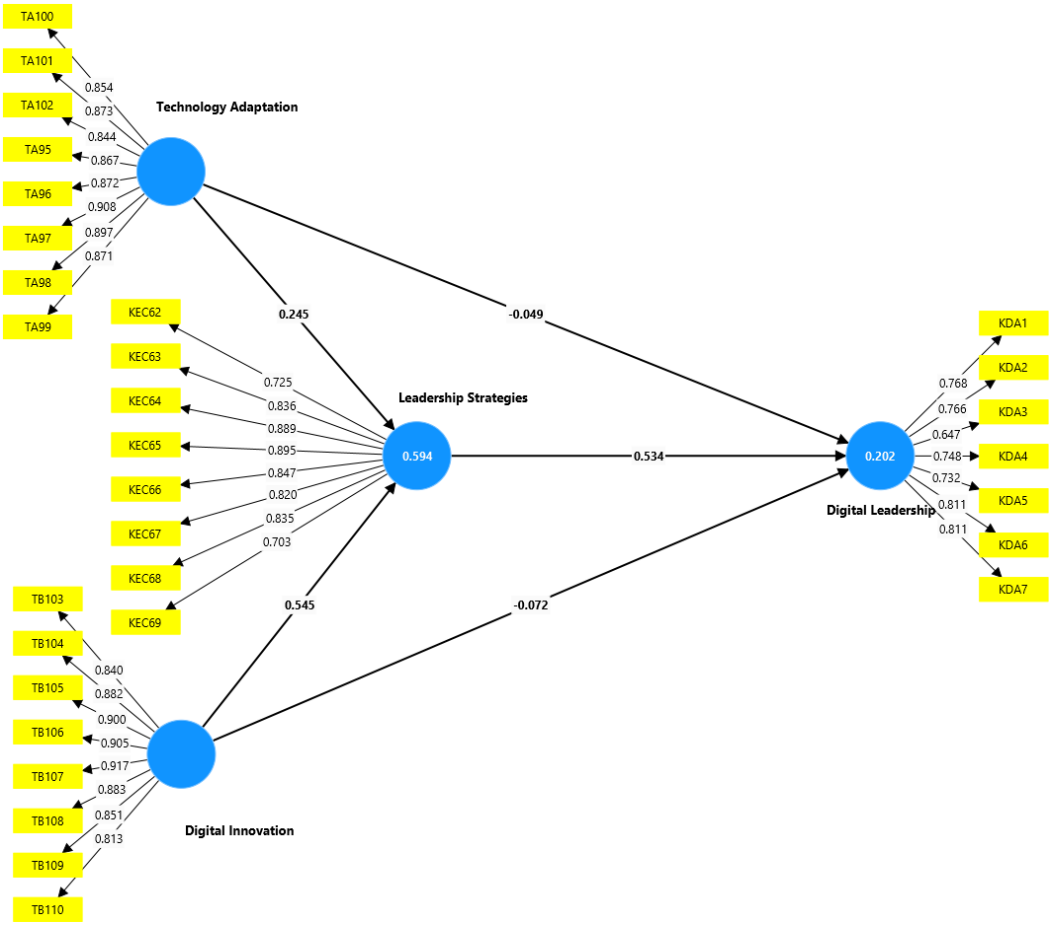


Figure 2.1: Measurement Model Analysis: Examines the relationship between technology adaptation and digital innovation with leadership strategies, and digital leadership.

Technology Adaptation Relationship and Leadership Strategy

Technology adaptation has a moderately positive relationship with leadership strategy, as shown by a coefficient of 0.245. This shows that an organization's ability to adapt to new technologies such as digital learning systems is able to contribute to increasing the effectiveness of leadership strategies. Elements such as TA100 to TA102 in this model demonstrate the factors that motivate leaders to formulate more appropriate strategies to ensure the adoption of technology by the organization. Although this influence is not too great, it still provides a foundation for leaders to support digital transformation through strategies that are in line with technological developments, such as involving teacher training in the use of digital tools and raising awareness on the need for innovation in learning.

Digital Innovation and Leadership Strategy Relationship

The relationship coefficient between digital innovation and leadership strategy was 0.545, indicating a more significant influence than technology adaptation. Factors such as TB103 to TB110, which are related to the implementation of innovative processes in educational technology, are driving leadership strategies in a more holistic and innovative direction. Leaders who take a digital innovation approach can align the use of new technologies with organizational strategy, for example by promoting virtual learning, educational data analytics, or collaborative platforms. This influence shows that digital innovation not only impacts the technology used, but also drives leadership to devise more flexible and resilient strategies in the face of the challenges of 21st century education.

Leadership Strategies as a Mediator to Digital Leadership

The relationship between leadership strategy and digital leadership shows a high positive coefficient, which is 0.534. This reinforces the role of leadership strategy as a key mediator in connecting technology adaptation and digital innovation to effective digital leadership. On the other hand, the direct correlation of technology adoption (-0.049) and digital innovation (-0.072) to digital leadership was weak or negative, indicating that without a good leadership strategy, these elements may not have a significant impact. This underscores the need for digital leaders to have a well-planned strategy, including the ability to drive a culture of innovation and technology acceptance within the organization. With a strong strategy, digital leadership can be implemented more effectively, ensuring that technology and innovation truly benefit the success of educational organizations.

Table 3.2
Relationship testing uses Path Coefficients and p-values to verify significant relationships

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Digital Innovation -> Digital Leadership	-0.072	-0.072	0.148	0.483	0.629
Digital Innovation -> Leadership Strategies	0.545	0.55	0.087	6.282	0
Leadership Strategies -> Digital Leadership	0.534	0.546	0.092	5.822	0
Technology Adaptation -> Digital Leadership	-0.049	-0.055	0.15	0.327	0.744
Technology Adaptation -> Leadership Strategies	0.245	0.243	0.094	2.596	0.009

The relationship between Technology Adaptation, Digital Innovation, Leadership Strategy, and Digital Leadership demonstrates the critical role each element plays in supporting an organization's digital transformation. In the relationship between Digital Innovation and Digital Leadership, a weak negative coefficient value (-0.072) with a low statistical T-value (0.483) and a high p-value (0.629) indicates that this relationship is not directly significant. This means that technological innovations such as the implementation of new systems are not enough to contribute to digital leadership unless they are supported by effective strategies. On the other hand, the relationship between Digital Innovation and Leadership Strategy was strong, with a coefficient of 0.545, a high statistical T-value (6.282), and a significant p-value (0.000). This relationship emphasizes that digital innovation influences the formation of more strategic and innovative leadership strategies.

Furthermore, Leadership Strategy showed a significant positive relationship to Digital Leadership with a coefficient of 0.534, a T-statistic of 5.822, and a p-value of 0.000. This shows that leadership strategy is a key driver of digital leadership effectiveness. These elements help make technology and innovation the foundation of a well-planned leadership approach, aligned with the needs of digital-age organizations. On the other hand, the direct relationship

between Technology Adaptation and Digital Leadership was weak (-0.049 coefficient) with a T-statistic of 0.327 and a p-value of 0.744, suggesting that technology adoption on its own did not have a significant impact on digital leadership without a leadership strategy as a link.

Finally, the relationship between Technology Adaptation and Leadership Strategy was moderate (coefficient 0.245) with a T-statistic of 2.596 and a p-value of 0.009. This suggests that an organization's ability to adapt technology makes an important contribution to the formation of leadership strategy, although not as strongly as the link to digital innovation. Therefore, the overall model emphasizes that leadership strategy acts as an important mediator, linking technology adoption and digital innovation to digital leadership success. Organizational leaders need to pay attention to well-designed strategies to leverage technology and innovation in realizing successful digital transformation.

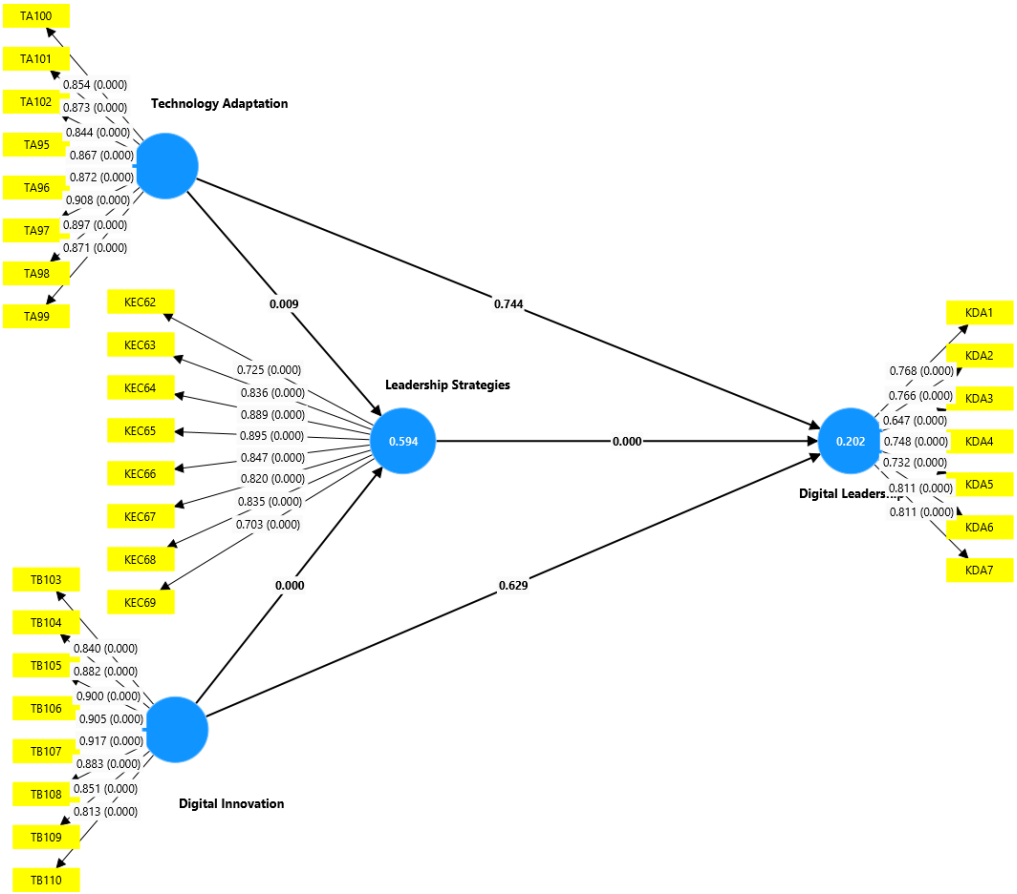


Figure 3.4: Analysis of relationship using Path Coefficient and P-Values

The model in the figure shows the relationship between Technology Adaptation, Digital Innovation, Leadership Strategy, and Digital Leadership, with Path Coefficient and P-Value values describing the strength and significance of the relationship. Path coefficient is an indicator of the strength of the relationship between independent and dependent variables, while the p-value determines whether the relationship is statistically significant (P < 0.05). Based on this model, there is a very weak positive relationship between Technology Adaptation and Leadership Strategy (path coefficient = 0.009) but significant (P = 0.009). This

suggests that technological adaptation contributes little to the formation of leadership strategies, although the impact is not large.

On the other hand, the relationship between Technology Adaptation and Digital Leadership (path coefficient = 0.744) showed a strong positive relationship but was not statistically significant (P = 0.744). This relationship suggests that technology adoption may be relevant but requires mediators, such as leadership strategies, to impact digital leadership. For Digital Innovation to Leadership Strategy, this relationship has a zero path coefficient (0.000), but it is very significant (P = 0.000). This means that digital innovation has a strong and significant direct impact in shaping leadership strategies that are in line with technological and digital developments. However, the direct relationship between Digital Innovation and Digital Leadership had a moderate (0.629) but not significant (P = 0.629) coefficient path. This relationship reflects that digital innovation without a clear strategy does not have a significant impact on the success of digital leadership. The relationship between Leadership Strategy and Digital Leadership showed a significant relationship (P = 0.000) even though the path coefficient was zero. This emphasizes the importance of leadership strategy as a critical component in supporting digital leadership.

Overall, this model shows that while Technology Adaptation and Digital Innovation are important in digital transformation, the role of Leadership Strategy is more critical. It acts as a mediator that connects technology and innovation with the effectiveness of digital leadership. Therefore, organizations need to focus on a strong leadership strategy to leverage technology adoption and digital innovation to achieve successful digital leadership.

Table 3.4
The Indirect Effects Test uses the p-value to verify a significant relationship

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Technology Adaptation -> Leadership Strategies -> Digital Leadership	0.131	0.133	0.059	2.233	0.026
Digital Innovation -> Leadership Strategies -> Digital Leadership	0.291	0.299	0.065	4.483	0.000

Relationship of Technology Adaptation, Leadership Strategies and Digital Leadership
The Original Sample (O) value of 0.131 reflects a small positive effect of Technology Adaptation on Digital Leadership through Leadership Strategy as a mediator. This indicates that while the direct impact of technology adaptation on digital leadership may not be substantial, its influence becomes meaningful when mediated by strategic leadership initiatives. The Sample Mean (M) value of 0.133, which is very close to the original effect, highlights the stability of this relationship, suggesting that the result is consistent across the different iterations of the sample.The Standard Deviation (STDEV) value of 0.059 signifies minimal variation, reinforcing the consistency of the observed relationship within the data sample. This consistency strengthens the reliability of the model in explaining the mediated relationship. Furthermore, the T-Statistics (|O/STDEV|) value of 2.233, which exceeds the critical threshold of 1.96 at a 95% confidence level, indicates that this mediated relationship

is statistically significant. The P-Value of 0.026, being less than the conventional significance level of 0.05, further confirms the statistical significance of this relationship.

In conclusion, the results imply that Technology Adaptation does contribute to Digital Leadership, but its effect is most effectively realized through the integration of Leadership Strategies. This highlights the importance of having robust and adaptive strategies in place to maximize the potential of technology adoption in enhancing digital leadership practices. Thus, organizations should focus not only on adopting new technologies but also on aligning them with well-structured leadership strategies to achieve impactful digital transformation.

Relationship of Digital Innovation, Leadership Strategies and Digital Leadership

The table highlights the mediated relationships between Technology Adaptation, Digital Innovation, and Leadership Strategy in shaping Digital Leadership. These relationships are assessed based on statistical values to understand their strength and significance. For the relationship Digital Innovation → Leadership Strategies → Digital Leadership, the Original Sample (O) value of 0.291 indicates that digital innovation has a greater positive effect compared to technology adaptation when mediated through leadership strategies. This demonstrates that innovation plays a critical role in strengthening digital leadership through strategic initiatives. The Sample Mean (M) of 0.299 is consistent with the original value, underscoring the stability and reliability of this relationship. The small Standard Deviation (STDEV) of 0.065 reflects limited variability, suggesting that the impact of digital innovation on leadership strategies is consistent across different sample scenarios. The T-Statistics (|O/STDEV|) value of 4.483 significantly exceeds the critical value of 1.96, confirming a high level of significance for this relationship. This is supported by the P-Value of 0.000, which strongly indicates that the relationship between digital innovation and digital leadership, mediated by leadership strategies, is statistically significant. These findings highlight the critical importance of digital innovation in shaping effective leadership strategies, which in turn drive success in digital leadership.

In contrast, the relationship Technology Adaptation → Leadership Strategies → Digital Leadership demonstrates a smaller Original Sample (O) value of 0.131, indicating a weaker positive effect compared to digital innovation. However, the T-Statistics value of 2.233 (greater than 1.96) and the P-Value of 0.026 (less than 0.05) confirm that this relationship is still statistically significant. This suggests that while technology adaptation contributes to digital leadership through leadership strategies, its impact is not as strong as digital innovation. Overall, the findings emphasize that Digital Innovation, when mediated by effective Leadership Strategies, has a more significant and stable impact on Digital Leadership compared to Technology Adaptation. This underscores the need for organizations and educational institutions to prioritize innovation-driven strategies to succeed in the digital era.

Discussion

Reliability and Validity

This study on the reliability and validity of digital transformation provides a strong view of the role of key elements such as digital innovation, digital leadership, leadership strategy, and technology adoption. The high reliability of the instrument indicates a strong internal consistency, providing a solid basis for further evaluation. In the context of education, this is especially important to support the implementation of digital transformation, such as the use

of data analytics and virtual learning technologies to improve the effectiveness of educational operations (Pelters, 2021; F5, 2024). The validity of convergence shows that the constructs used are relevant in understanding the relationship between these elements and the success of the organization. For example, strategies such as data observation and automation play a critical role in ensuring that data can be managed more efficiently to support innovation (Acceldata, 2024). Studies also show that effective digital leadership is an important foundation for organizational culture change, motivating employees to embrace new technologies (Eberl & Drews, 2021).

The study also highlights the link between leadership strategies and digital innovation, where a collaborative and efficiency-based approach can drive digital transformation outcomes. Recent studies confirm that active involvement of leaders in integrating technology into organizational processes can improve organizational resilience and flexibility to rapidly changing technological challenges (Mann et al., 2022; Innovation-Entrepreneurship, 2024). Overall, while the findings of the study show encouraging results, challenges such as work culture and infrastructure constraints need to be addressed through a more integrated strategic approach. Recent studies call for the use of AI-assisted technologies and cloud-based platforms to address these issues, thus strengthening organisations' ability to capitalise on digital transformation opportunities (Acceldata, 2024; Forbes, 2024).

Relationship between Leadership Strategy, Emotional Intelligence, and Digital Leadership

Based on the analysis of the relationship between digital transformation dimensions such as digital innovation, leadership strategy, technology adaptation, and digital leadership, there are important findings that should be reviewed argumentatively. This analysis, when compared with the contents of the file, suggests that certain relationships may require deeper attention, particularly in educational contexts. The insignificant relationship between digital innovation and digital leadership suggests that in-person innovation may not be enough to drive digital leadership change. While innovation provides new tools and technologies, their effectiveness is often limited if the leader's work culture and strategic vision are not aligned with the change. A study by Luqman Hadi (2021) emphasizes that digital leadership requires a positive role model to encourage technology adoption by teachers. This is also supported by Eberl and Drews (2021), who emphasized the importance of strategic leadership focused on changing organizational culture in the context of digital transformation.

On the other hand, the significant relationship between digital innovation and leadership strategy demonstrates the ability of innovation to strengthen an organization's strategic foundation. In the file, Aminah (2010) and Syntax Admiration (2023) suggest that the integration of technologies such as data analytics and virtual learning can improve teaching effectiveness, despite challenges such as infrastructure constraints. Therefore, leadership strategies that leverage this technology can have a significant impact on the success of digital transformation, as demonstrated by the success of the DELIMa platform in Malaysia (Raja Noor Alina & Mastura, 2018). Additionally, the positive relationship between leadership strategy and digital leadership reflects the important role of strategy in supporting change. The study of Bolman and Deal (2003) in the file emphasizes that a multidimensional leadership model that combines structural, symbolic, human capital, and political aspects is particularly relevant to lead technological change. These findings are in line with the opinion

of Innovation-Entrepreneurship (2024), which suggests that smart leaders aligning their strategies with organizational needs can drive adoption of new technologies.

However, the significant relationship of technology adaptation only to leadership strategy, and not to digital leadership, demonstrates potential challenges in aligning technology with leadership processes. The study by Octavia and Alamsjah (2023) in the file states that technology adaptation needs to be accompanied by the support of an agile organizational culture. This is important to ensure that elements of technology not only impact strategy, but also empower digital leadership through capacity building and cultural change (F5, 2024; Forbes, 2024). In conclusion, this analysis reflects the complex interaction between digital transformation elements. While certain relationships such as digital innovation to digital leadership are insignificant, this does not negate the great potential of these elements if supported by the appropriate organizational strategy and culture. Sustainable digital transformation requires a holistic approach that integrates technology with a strategic vision and a progressive work culture. This can be achieved through change-focused leadership, supported by the knowledge and use of modern technologies such as AI and data platforms (Acceldata, 2024; Syntax Admiration, 2023).

Significance of the Relationships

The findings of the analysis show that leadership strategies play an important role as a link between technology adoption, digital innovation, and digital leadership. Significant indirect relationships through leadership strategies reinforce the argument that technology and innovation alone are not enough to drive change, unless underpinned by a strategic and planned leadership approach. This is in line with the arguments in the file, which assert that strategic leadership helps shape the vision, manage resources, and encourage collaboration within the organization to ensure the success of digital transformation (Bolman & Deal, 2003; Journal of Leadership in Education, 2024).

The significant relationship between technology adaptation through leadership strategies towards digital leadership shows that technology only becomes an effective tool when adapted to the needs and culture of the organization. In the context of education, the successful implementation of platforms such as DELIMa in Malaysia depends on the support of a leadership strategy that leverages intensive training and adequate infrastructure. This approach proves that a holistic strategy can increase technology adoption and support the construction of a proactive work culture (Raja Noor Alina & Mastura, 2018; Octavia & Alamsjah, 2023)1.

On the other hand, the significant relationship between digital innovation through leadership strategy to digital leadership underlines the role of innovation as a key driver in shaping organizational strategy. The study in the file shows that the integration of innovative technologies such as virtual learning and data analytics can improve the effectiveness of educational organizations, despite constraints such as a less supportive work culture or infrastructure problems (Aminah, 2010; Syntax Admiration, 2023). This study emphasizes that leadership strategies adapted to digital innovation are able to generate sustainable change and support the effectiveness of digital leadership.

Overall, these findings underline the need for a more holistic and strategic leadership approach in ensuring the success of digital transformation. While technology adaptation and digital innovation are important, a thoughtful leadership strategy is a key determining factor in connecting these elements to digital leadership success. Studies in the file consistently show that organizational culture change and leader capacity building are key to the effectiveness of digital transformation strategies (Luqman Hadi, 2021; Aminah, 2010)

Conclusion and Recommendations

The review and synthesis of previous studies reveal that technology adaptation, digital innovation, leadership strategy, and digital leadership are interdependent and collectively contribute to meaningful and sustainable digital transformation, particularly in the context of educational institutions. While technology and innovation are often positioned as the main drivers of change, their actual effectiveness is shaped significantly by how leadership strategies are formulated and executed. Findings from the literature underscore that leadership strategy plays a pivotal intermediary role acting as the bridge between digital innovation and digital leadership. In other words, innovation alone does not guarantee effective digital leadership unless it is embedded within a broader strategic framework that aligns with institutional goals, human capacity, and available infrastructure. This echoes insights from various scholars who assert that strategic leadership enables the alignment of technological initiatives with the organisation's cultural, pedagogical, and operational realities (Octavia & Alamsjah, 2023; Bolman & Deal, 2003; Raja Noor Alina & Mastura, 2018).

The case of Malaysia's DELIMa platform serves as a real-world illustration of how leadership strategies such as targeted training programs, infrastructure upgrades, and stakeholder engagement, can enhance the adoption of digital tools and platforms. It also demonstrates that successful transformation requires more than just introducing new technologies; it demands coordinated efforts in capacity building, resource mobilization, and change management. Interestingly, the direct relationship between technology adaptation and digital leadership appears to be less influential without strategic mediation. This implies that the mere presence of digital tools or systems is insufficient to develop strong digital leadership. Instead, there is a critical need to nurture an organizational culture that values innovation, continuous learning, and adaptive leadership. These insights support the broader conclusion that digital transformation in schools should be approached holistically which not as a series of isolated technological interventions, but as an integrated change process driven by vision, people, and purpose. Leadership that is both strategic and emotionally intelligent is essential in cultivating this ecosystem.

To ensure successful digital transformation in schools, several strategic recommendations must be considered. First, there is a pressing need to invest in strategic leadership development by equipping educational leaders with future-ready competencies such as digital literacy, systems thinking, innovation management, and emotional intelligence. This calls for professional development programs that go beyond technical skills to include reflective leadership practices, coaching, and peer mentoring. In parallel, institutions should establish comprehensive policy frameworks that align technology, pedagogy, and leadership goals, supported by adequate resources, clear performance indicators, and mechanisms for innovation diffusion. A supportive organizational culture must also be cultivated with encourages experimentation, risk-taking, and shared leadership.

Central to this is the development of professional networks and collaborative platforms that allow for the exchange of best practices and peer learning across schools. Moreover, digital initiatives must be underpinned by strong and inclusive infrastructure to ensure equitable access, particularly in rural and underserved contexts. Equally important is the promotion of data-informed decision-making, where leaders use analytics and reflective practices to evaluate the impact of digital strategies and drive continuous improvement. Finally, emotional intelligence should be integrated into leadership practices to help manage change with empathy, navigate resistance, and sustain motivation among educators. Together, these recommendations offer a holistic pathway for fostering strategic, inclusive, and human-centered digital leadership in schools.

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