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TECHNOLOGY READINESS AS A MEDIATOR BETWEEN TRANSFORMATIONAL LEADERSHIP AND DIGITAL LEARNING EFFECTIVENESS

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Abstract

Digital transformation in the education sector demands adaptive leadership and mature technology readiness to achieve the effectiveness of digital learning. This study aims to examine the relationship between transformational leadership and the effectiveness of digital learning, with technology readiness as a mediating variable. A quantitative approach was utilized through Structural Equation Modeling (SEM) based on SmartPLS 4. The research sample involved 52 teachers from various schools that have implemented digital learning using purposive sampling techniques. The instruments used included the Multifactor Leadership Questionnaire (MLQ), Technology Readiness Index (TRI), and indicators of digital learning effectiveness from Anderson (2008). The analysis results show that transformational leadership does not have a direct effect on the effectiveness of digital learning ($p > 0.05$), but has a significant effect on technology readiness ($p < 0.001$). Technology readiness significantly affects the effectiveness of digital learning ($p < 0.001$) and has been shown to mediate the relationship between transformational leadership and the effectiveness of digital learning. The indirect effect of transformational leadership on digital learning effectiveness through technology readiness was substantial ($\beta = 0.589$, $p < 0.001$). These findings emphasize the importance of technology readiness as a key to success in the implementation of effective digital learning. This research provides practical implications for educational institutions in designing sustainable digital transformation strategies that focus on human resource readiness.

Keywords: transformational leadership; technology readiness; digital learning effectiveness; structural equation modeling; SmartPLS.

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INTRODUCTION | مقدمة

In the last decade, digital transformation has revolutionized global education systems, pushing institutions to integrate technology thoroughly into the learning process. This change has been further accelerated by the COVID-19 pandemic, which required educational institutions to adapt drastically through online or blended learning models. However, the adoption of technology in education does not automatically guarantee effective learning. It requires readiness of human resources, infrastructure readiness, and leadership capable of steering digital transformation strategically and sustainably (Dhawan, 2020).

Transformational leadership is a leadership style that focuses on developing the potential of the team, creating a common goal, and encouraging positive change within the organization. Kuhnert & Lewis (1987) used the theory from Burns (1978) and developed it further by Bass (1985), which explains that transformational leaders can enhance spirit, motivation, and performance by being good role models, providing inspiration, encouraging creative thinking,

and paying attention to individual needs. In the field of education, such leaders are essential for fostering innovation and embracing new technologies. According to Salsabila et al. (2024) quoting Bass & Avolio (1994), there are four key elements in measuring transformational leadership, namely: building trust, providing an inspiring vision, encouraging creative thinking, and paying attention to the needs of each team member. This is very helpful in creating an inclusive and supportive digital learning environment. Although prior studies have examined transformational leadership and digital learning effectiveness separately, limited evidence addresses how technology readiness mediates this relationship, particularly in the Indonesian educational context. This study contributes by integrating the TRI model into leadership and learning effectiveness frameworks, offering both theoretical enrichment and practical guidance for digital transformation in schools.

In the context of educational organizations, the role of leadership becomes crucial. Transformational leadership style, characterized by the ability to inspire, motivate, and empower members of the organization, has proven to drive change and innovation, including in technology integration (Bass & Riggio, 2006; Chang & Octoyuda, 2024). Nevertheless, the effectiveness of transformational leadership in improving digital learning outcomes still shows variations, especially when not accompanied by adequate technological readiness (Montasser et al., 2023). Some studies emphasize that strong leadership alone is not enough—readiness for technology, both from the individual and organizational sides, becomes a determining factor in the success of learning digitalization (Höyng & Lau, 2023).

The Technology Readiness Index (TRI) developed by Parasuraman (2000) has become an important measurement tool in assessing this technology readiness. The dimensions of optimism, innovation, discomfort, and insecurity serve as key indicators of readiness to accept and use new technology. However, studies on the mediating role of technology readiness in the relationship between transformational leadership and digital learning effectiveness are still limited, especially in the context of Indonesian education. Most previous studies have focused more on the direct effects between leadership and learning performance without considering the psychological and technological factors that bridge that relationship.

According to Subroto et al. (2023), it shows that the more prepared the technology is, the more successful the digital learning will be. Schools or universities that are ready have teachers who are skilled at using online learning platforms (LMS), have good IT facilities, and strong administrative support. If the readiness is lacking, then digital learning will be difficult to run effectively. In addition to individual readiness, we also need to assess organizational readiness. A prepared organization has a supportive structure, a culture that embraces change, and adequate technology. These three aspects must work together for the transition from traditional learning to digital learning to proceed smoothly. Thus, technological readiness must be viewed in its entirety, not just from the user's perspective (Aydin & Tasci, 2005).

According to Dwivedi et al. (2021), it emphasizes the importance of a well-thought-out plan to improve technology readiness in education. They suggest continuously training the use of technology, providing sufficient digital resources, and establishing clear rules about digital transformation. In this way, technology readiness can be a strong bridge between good leadership and effective learning.

The effectiveness of digital learning is how successfully the learning objectives are achieved through digital media. We can observe this from students' learning outcomes, how actively they are engaged, how satisfied they are, and how well the interactions in their learning are (Al-Fraihat

et al., 2020). In the digital world, good learning design, adequate technological support, and teachers' digital skills are crucial for the success of learning. According to Putri (2023), the quality of interaction between students and teachers, ease of access to materials, and the use of interactive technology significantly affect the effectiveness of online learning. The better the design and implementation, the more satisfied the students will be and the higher their learning outcomes will be. Therefore, effectiveness is not just about grades, but also about how students feel about their learning process.

Then, Sulistyowati & Asriati (2024), show that good leadership and technology readiness are important factors that make digital learning increasingly effective. Leaders with vision will provide direction and support, while technology readiness ensures the resources and capabilities available to support the teaching and learning process. When all three work well together, then digital transformation in education can succeed.

Several previous studies have examined the crucial role of digital leadership in realizing digital transformation, by utilizing information technology in work processes that will increasingly be assisted, thus researchers found that the readiness of the organization and how the leadership style adapts to technology significantly influences the success of digitization (Tulungen et al., 2022). On the other hand, research conducted by Maryati & Siregar (2022) states that the significant use of ICT can connect leadership with organizational performance, hence transformational leadership can affect the effectiveness of digital learning through technology readiness as an intermediary. Moreover, the research conducted by Permana et al. (2024), shows that digital technology can enhance student engagement, understanding of the material, and learning motivation. This finding supports the importance of technological readiness in making digital learning successful.

From the previous researchers, it can be concluded that conditions in the field show that many schools in Indonesia are implementing technology hastily without a comprehensive readiness assessment. As a result, digital transformation is less than optimal, even counterproductive to the quality of education. Therefore, research is needed that not only looks at the role of leadership and technology separately but also understands how the interaction of both contributes to the effectiveness of digital learning. Hence, this study aims to empirically examine the relationship between transformational leadership and the effectiveness of digital learning while considering technology readiness as a mediating variable. By using a quantitative approach through the Structural Equation Modeling (SEM) method based on SmartPLS 4, this study presents findings that can enrich the literature related to digital leadership and provide practical contributions for education policymakers.

Thus, the main objective of this research is to investigate the extent to which transformational leadership affects the effectiveness of digital learning through technology readiness as a mediator, in the context of schools that have implemented a digital-based learning system.

METHOD | منهج

This research uses a quantitative method with a correlational type. The main objective is to test the relationship between transformational leadership, technology readiness, and the effectiveness of digital learning, as well as to analyze the mediating role of technology readiness. Data was collected through an online questionnaire distributed to teachers from schools that have implemented digital learning using a Likert scale of 1–5, which is commonly used in social

research to measure how much respondents agree with certain statements (Sugiyono, 2021). The instruments used were adjusted based on indicators that have been proven valid from previous studies. The collected data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4. PLS-SEM was chosen because it is suitable for predictive and exploratory research, can handle complex mediation models with relatively small sample sizes, and is appropriate when the theoretical framework is still developing (Hair et al., 2019). All latent constructs in this study were modeled reflectively, as each indicator represents the manifestation of its underlying construct (Ghozali & Latan, 2015).

Subsection Identification

Population and Sample

The population in this study consists of teachers from schools that have implemented digital learning (online or blended learning). The sampling technique used is purposive sampling, which means we select samples based on specific criteria that align with the research objectives (Arikunto, 2013). The criteria are: (1) has experience using digital learning for at least one year, (2) has access to learning technology, and (3) is involved in making decisions or implementing policies regarding digital learning. The sample size is determined based on the SEM formula, which is a minimum of 5 to 10 respondents for each research indicator (Hair et al., 2019). In this study, there are a total of 52 respondents.

Research Design

This research uses a quantitative method with a correlational type. This correlational approach is suitable because we want to understand the extent to which these variables are related based on the available data. The main objective is to test the relationship between transformational leadership, technology readiness, and the effectiveness of digital learning, as well as to analyze the mediating role of technology readiness.

Data Collection Technique

The main way to collect data in this research is by using an online questionnaire. The questionnaire uses a five-point Likert scale, which is commonly used in social research to measure how much respondents agree with certain statements (Sugiyono, 2021). We chose the online format because it is more flexible and can reach more people.

The questions in the questionnaire are arranged based on indicators that have been proven valid from previous studies. For example, to measure transformational leadership, we use an adaptation of the Multifactor Leadership Questionnaire (Bass & Avolio, 1994), and to measure technology readiness, we use the Technology Readiness Index (Parasuraman, 2000) which has been adjusted to the conditions here, and the Digital Learning Effectiveness from Anderson (2008) that focuses on cognitive, affective, and collaborative aspects.

Before distribution, the instrument is tested for validity and reliability. Validity is tested through expert judgment and CFA, while reliability is measured using Cronbach's Alpha with a value of > 0.70 to be considered reliable (Ghozali, 2018).

Data Analysis Technique

The collected data will be analyzed using Structural Equation Modeling (SEM) with the help of software such as SmartPLS. SEM is chosen because this method can test cause-and-effect relationships between concepts simultaneously and can analyze complex mediating roles (Ghozali & Latan, 2015).

The first step in the analysis is to test whether the instruments are valid and reliable using Confirmatory Factor Analysis (CFA). The goal is to ensure that the questions in the questionnaire truly measure the concepts that are intended to be measured. For reliability, the Composite Reliability and Cronbach's Alpha values will be examined. To test whether technology readiness acts as a mediator, the bootstrapping method will be used. This method is recommended in mediation analysis because it provides accurate estimates for mediation effects and is not heavily dependent on the assumption that the data must follow a normal distribution (Hayes, 2017). Although the sample size (N = 52) meets the minimum threshold recommended for PLS-SEM—five to ten times the number of indicators—it remains a methodological limitation. Future studies with larger and more diverse samples are encouraged to improve the generalizability and robustness of the findings.

RESULT | نتائج

Based on the theoretical explanation of the relationship between variables outlined above, a research model can be developed as follows in the previous sub-chapter:

Figure 1 shows how the relationships between variables in this study are modeled. From this model, it can be seen that there are four hypotheses formulated as follows:

H1: Transformational leadership does not have a direct effect on the effectiveness of digital learning.

H2: Transformational leadership positively affects technology readiness.

H3: Technology readiness positively affects the effectiveness of digital learning.

H4: Technology readiness mediates the relationship between transformational leadership and the effectiveness of digital learning.

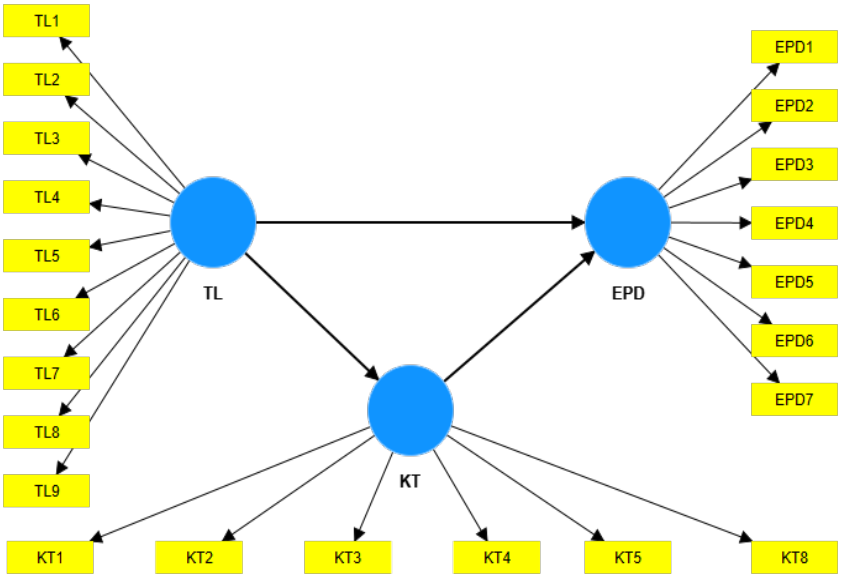

Figure 1. Research Design Model and Hypothesis

Research Data Analysis

In this research, data analysis will be conducted in two stages, namely the analysis of the outer model and the inner model. The outer model test aims to determine the relationship between latent variables and their indicators by using the PLS Algorithm procedure. This study evaluates the outer model using validity and reliability tests. To measure data reliability, Cronbach's Alpha is used with a minimum acceptable value of 0.5, while the ideal value ranges from 0.7. In addition to Cronbach's Alpha, composite reliability values are also used and interpreted similarly to Cronbach's Alpha. Reflective indicators must be excluded from the measurement model if their outer standard loading value is below 0.4.

Researchers will also examine the validity of the research instrument items by looking at the factor loading values. The factor loading values indicate the correlation between indicators and constructs. The threshold for factor loading is set at 0.5. If the factor loading value is > 0.5, then convergent validity is met; if the factor loading value is < 0.5, then the construct must be dropped from the analysis (Ghozali, 2014).

In the next stage, researchers will test the inner model to predict causal relationships between latent variables or variables that cannot be measured directly. The inner model describes the causal relationships between latent variables that are based on the substance of theory. Testing of the structural model is conducted to examine the relationships between latent constructs, using the R Square value to evaluate endogenous constructs. The R Square value indicates the coefficient of determination for endogenous constructs, which shows how well independent variables explain the variance in the dependent variable. According to Chin (1998), R Square values are categorized as 0.67 (strong), 0.33 (moderate), and 0.19 (weak).

Test of Validity and Reliability

The outer loading section indicates the validity of items per indicator if the obtained value is > 0.7. From the analysis that the researcher has conducted, as shown in table 1, there is one item with a value less than 0.7, namely KT8. To address this, a common method used by researchers is to delete or replace such items.

However, in this study, the item is retained based on the AVE value criteria. The AVE value should be equal to 0.5 or > 0.5. In the AVE value column, it can be seen that one variable has a value of 0.437, which indicates that this value meets the criteria for construct validity as it approaches 0.5.

Meanwhile, to measure the reliability of the indicators, one can look at Cronbach's alpha, rho_a, and composite reliability, where all three categories are considered to have good reliability if the significance value > 0.7 (Ghozali & Latan, 2015).

Table 1. Loading Factor, Cronbach's alpha, Rho_a, Rho_c, and AVE

Dimension	Factor Loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
EPD1	0.906				
EPD2	0.779				
EPD3	0.827				
EPD4	0.922	0.948	0.949	0.958	0.766
EPD5	0.915				
EPD6	0.872				
EPD7	0.895				
KT1	0.906	0.912	0.941	0.936	0.719

KT2	0.893				
KT3	0.904				
KT4	0.913				
KT5	0.926				
KT8	0.437				
TL1	0.922				
TL2	0.934				
TL3	0.869				
TL4	0.911				
TL5	0.897	0.965	0.968	0.970	0.783
TL6	0.908				
TL7	0.852				
TL8	0.793				
TL9	0.871				

The table above shows that the values of the three categories are > 0.7. The values of Cronbach's Alpha range from 0.912 to 0.965. The values of rho_a range from 0.941 to 0.968. And the values of Composite Reliability range from 0.936 to 0.970. All of these values exceed 0.7.

Inner Model

To determine the effect of transformational leadership variables on the effectiveness of digital learning variables, the researcher refers to the R-square value. Based on the analysis results, the following values were obtained as shown in the table below:

Table 2. R-Squared Value

Dimension	R-square	R-square adjusted
Effectiveness of digital learning	0,827	0,820

The analysis results show that the R-square value is 0.827, indicating that the model explains 82.7% of the variance in digital learning effectiveness. According to Chin (1998), R^2 values of 0.67, 0.33, and 0.19 are categorized as strong, moderate, and weak, respectively. Therefore, an R^2 of 0.827 indicates a strong level of explanatory power, suggesting that transformational leadership and technology readiness together have a substantial predictive capability for digital learning effectiveness.

Hypothesis Testing

To evaluate significance, it is important to check the T-Statistic and P-Values between independent and dependent variables. The research hypothesis is accepted if T-Statistic > 1.96 and P-Values < 0.05 (Iba & Wardhana, 2024).

Table 3. Results of path coefficient analysis with SmartPLS

Dimension	Original sample	Sample mean	Standard deviation	T statistics	P values
KT -> EPD	0,828	0.814	0.084	9.814	0.000
TL -> EPD	0,110	0.122	0.091	1.212	0.225
TL -> KT	0,712	0.717	0.107	6.624	0.000

Based on the results in Table 3 above, it shows that the proposed hypothesis can be accepted. Therefore, the test results for each hypothesis are as follows:

To address the first hypothesis regarding the influence of transformational leadership on the effectiveness of digital learning, it can be seen in Table 3 that the P value is 0.225 > 0.05 and the T-Statistic value reaches 1.212, which is > 1.96. This indicates that directly, the transformational leadership variable does not have an effect on the effectiveness of digital learning. Therefore, H1 is rejected.

For the second hypothesis regarding the influence of transformational leadership on technological readiness, it can be seen that the P value is 0.000 < 0.05 and the T-statistic value reaches 6.624, which is > 1.96. This indicates that the transformational leadership variable has a positive and significant influence on technological readiness. Therefore, H2 is accepted.

Next, for the third hypothesis regarding the influence of technological readiness on digital learning effectiveness, the results in the table show that the P value is 0.000 < 0.05 and the T-statistic value reaches 9.814, which is > 1.96. This indicates that the technological readiness variable has a positive and significant influence on digital learning effectiveness. Therefore, H3 is accepted.

It can be concluded that, directly, transformational leadership does not significantly affect digital learning effectiveness by 0.110. Transformational leadership directly influences technology readiness by 0.712, and technology readiness directly affects digital learning effectiveness by 0.828.

Table 3. Results of path coefficient analysis with SmartPLS

Dimension	Original sample	Sample mean	Standard deviation	T statistics	P values
TL -> KT -> EPD	0.589	0.582	0.102	5.799	0.000

For testing the hypothesis of indirect influence, the results in Table 4 show that transformational leadership indirectly affects the effectiveness of digital learning through technology readiness. The magnitude of the indirect effect is 0.589 ($p < 0.001$), indicating a statistically significant mediation effect. Although SmartPLS did not display the confidence interval values explicitly, the bootstrapping results confirmed that the indirect path was significant at the 95% confidence level, ensuring the robustness of the mediation effect. This implies that the mediation role of technology readiness remains stable across repeated bootstrapping samples, supporting its reliability as a mediating construct (Hair et al., 2022). This indicates that the higher the quality of transformational leadership perceived by teachers, the higher the technology readiness they feel, which ultimately has a positive impact on the improvement of digital learning effectiveness.

DISCUSSION | مناقشة

The results of this study indicate that transformational leadership does not directly influence the effectiveness of digital learning, as evidenced by a p-value greater than 0.05 and a T-statistic lower than 1.96. These findings align with the research of Montasser et al. (2023), which states that in the context of educational digitization, the influence of leadership on effectiveness is often not linear, but rather depends on the internal readiness of the organization and the individual's readiness for technology.

On the contrary, the test results indicate that transformational leadership has a significant impact on technological readiness. This suggests that leaders who can provide inspiration, support, and motivation to their subordinates tend to create a work environment that is open to technological innovation. In line with Hargitai & Bencsik (2023), transformational leadership can

create positive psychological conditions and enhance individual confidence in adopting new technologies.

Furthermore, the analysis results indicate that technology readiness plays a significant role in the effectiveness of digital learning. This emphasizes that the adoption of technology in education is not only about the availability of devices but also the readiness of users to understand, manage, and integrate technology into the learning process (Höyng & Lau, 2023). The dimensions of optimism and innovation in the Technology Readiness Index (TRI) have proven to be key determinants of success in the effective use of technology.

Indirectly, transformational leadership has a positive impact on the effectiveness of digital learning through the mediation of technology readiness. This means that the role of leaders in creating psychological and technological readiness is crucial to bridging digital transformation in education. These results confirm Hamid (2022) study that shows technology readiness is a key enabler in enhancing the positive impact of leadership on digital-based learning performance.

Therefore, it can be concluded that in the context of digital learning, the effectiveness of implementation is not only influenced by leadership style, but further influenced by the extent to which organizations and individuals are ready to accept and optimally utilize technology.

However, this study acknowledges certain methodological limitations. The relatively small sample size (N = 52) limits generalizability, and the use of a reflective model might not fully capture the formative nature of digital readiness. Future studies could explore alternative model specifications and larger samples to confirm these relationships across different educational contexts.

Furthermore, this study acknowledges several additional limitations that should be considered when interpreting the findings. First, all variables were measured through self-reported questionnaires, which may introduce social desirability bias. Second, the absence of student learning data restricts the evaluation of digital learning effectiveness only to teachers' perceptions. Finally, the study primarily emphasized the positive dimensions of technology readiness namely optimism and innovativeness. Conversely, the negative dimensions of this readiness, specifically discomfort and insecurity, were not explored in depth. Future research should address these aspects to better understand psychological barriers in adopting educational technology.

CONCLUSSION | خاتمة

This study concludes that transformational leadership does not have a directly influence the effectiveness of digital learning, but significantly influences it through the mediation of technology readiness. These findings reaffirm that leadership indirectly promotes the effectiveness of teachers' digital learning by fostering a supportive and technology-oriented mindset.

Theoretically, this study contributes by integrating the Technology Readiness Index (TRI) into the transformational leadership framework, highlighting how psychological readiness mediates the impact of leadership on educational innovation.

Practically, the results emphasize that educational institutions must move beyond general digital training. Instead, leadership development programs and teacher workshops should be specifically designed based on the four dimensions of the TRI: optimism, innovation, discomfort, and insecurity. This is used to address motivational and psychological barriers. For example, TRI-

based workshops for principals can help them more strategically assess and improve their teachers' technology readiness. Structural supports, such as digital mentoring systems and peer coaching, are also important for maintaining ongoing readiness.

Despite providing valuable insights, this study acknowledges several limitations. The small sample size (N = 52) and self-reported data limit generalizability, while the exclusion of negative TRI dimensions limits the depth of analysis.

Future research should test this model at the institutional level to understand how organizational culture, policies, and infrastructure moderate the relationship between leadership, readiness, and digital learning outcomes. Extending the analysis beyond the teacher level would provide a more comprehensive understanding of the dynamics of digital transformation in education.

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