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Technology-Based Education Policy: Development and Implementation in the Education System

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A B S T R A C T

The rapid advancement of digital technology has encouraged the implementation of technology-based education policies in Indonesia to enhance educational quality and equity. This study aims to analyze the implementation of these policies by examining infrastructure readiness, educators' digital competence, and institutional policy support across different regional contexts. A mixed methods approach was employed, involving a survey of 600 teachers and school principals selected through stratified random sampling, complemented by interviews and focus group discussions with 25 key informants. Quantitative data were analyzed using exploratory factor analysis (EFA), structural equation modeling (SEM), and multilevel modeling, while qualitative data were analyzed thematically. The findings indicate significant disparities in technology readiness among regions. EFA identified infrastructure readiness, digital competence, and institutional support as the primary determinants of policy implementation. SEM results showed that infrastructure readiness had the strongest direct influence on implementation outcomes, while multilevel analysis revealed better performance among urban and senior high schools. Qualitative findings confirmed that limited connectivity, inadequate devices, and insufficient technical support remain major challenges, particularly in rural and 3T areas. The study concludes that successful implementation of technology-based education policies requires integrated investments in infrastructure, educator capacity development, and institutional support to promote equitable digital transformation in education.

1. Introduction

The development of information and communication technology (ICT) in education has become a significant global phenomenon over the past two decades (Warsita, 2018). Digital technology not only changes the way learning is managed, but also expands access, flexibility, and methods of interaction between students and

educators (Norpin et al., 2024). In Indonesia, digital transformation in the education sector is becoming increasingly evident with the growing use of the internet and digital technology for learning purposes (Sumarno, 2023). According to data from the Central Bureau of Statistics (BPS), approximately 59.33% of students aged 5–24 use the internet for learning activities, a substantial increase from previous years, indicating that technology has become an essential part of the teaching and learning process at various educational levels. This proportion varies from elementary school to college, with higher levels showing a trend toward more intensive internet usage (Hutagalung et al., 2024).

The advancement of digital technology has prompted educational institutions in Indonesia to adopt various digital devices and learning tools as part of the learning process (Aminah & Saksono, 2021). The Ministry of Education recorded a significant increase in the use of digital technology in educational units, especially since the school digitalization policy and the implementation of the Merdeka Curriculum (Sholeh et al., 2025). More than 60% of schools in Indonesia are reported to have integrated digital technology into their curriculum and learning processes, whether through the use of interactive learning media, online learning platforms, or learning management systems (Lie et al., 2020). This data shows that technology is no longer positioned as a supplement, but is beginning to become part of the formal learning structure in schools.

Nevertheless, the level of technological integration has not been uniform. Schools in urban areas generally have better preparedness compared to schools in rural areas and disadvantaged regions (Hartati et al., 2023). This difference is evident in the availability of ICT devices, the quality of internet networks, and the technical support received by schools. Educational data shows that schools in urban areas have a significantly higher internet access rate compared to schools in rural areas, allowing for more intensive and sustainable implementation of technology-based learning (Sung et al., 2016).

Data from the Ministry of Education, Culture, Research, and Technology's Dapodik also shows an increase in the number of registered and digitized educational units in recent years. This increase not only reflects the quantitative expansion of access to education but also demonstrates the government's systematic efforts to build a national education database integrated with digital technology (Handayani et al., 2024). Through the Dapodik system, schools are encouraged to utilize technology in managing data on students, educators, facilities and infrastructure, as well as online and real-time educational reporting.

In addition, educational statistical data released by the Central Bureau of Statistics in various regions, including Semarang City, shows that internet usage for educational purposes continues to increase. The percentage of students and educators using the internet as a learning resource increases annually, driven by the growing ownership of digital devices and the expansion of internet networks (BPJS Indonesia, 2023). This trend indicates that the Indonesian education ecosystem is becoming increasingly accustomed to the use of digital technology, both in learning and in educational management (KewalRamani et al., 2018).

However, the increasing adoption of these technologies and learning tools also reveals new challenges in the implementation of technology-based education policies (Tondeur et al., 2017). Differences in infrastructure readiness, educators' digital competence, and schools' capacity to integrate technology pedagogically indicate that technology adoption has not been fully proportional to improvements in learning quality (Voogt & Roblin, 2012). This condition confirms that the success of technology-based education policies is not solely determined by the availability of digital devices and systems, but also by the policy's ability to bridge regional gaps and sustainably improve the readiness of educational human resources.

This development underpins the shift in the learning paradigm from solely traditional face-to-face methods to more hybrid and digital learning. Learning models such as blended learning, virtual classrooms, and digital learning management systems (LMS) are now increasingly implemented as part of modern learning practices (Bradley, 2020; Rakes, 1996). However, this condition also reveals real challenges related to equitable access and the integration of technology in education. In its implementation, technology-based education policies in Indonesia have experienced complex dynamics. On one hand, the government has issued various strategies and programs to promote the digitalization of education, including the development of digital learning platforms, digital literacy strengthening programs, and support for improving educators' digital competencies (Tintingon et al., 2023). The Learning Management System (LMS) used in many schools supports online and blended learning processes, but the reality on the ground shows variations in infrastructure readiness and the capabilities of educators in different (Wang et al., 2024). The unequal access to technology in underdeveloped regions like the 3T areas (remote, outermost, and underdeveloped) often poses a major obstacle to the effective implementation of this policy (Wika, 2025).

Empirical findings also indicate that in addition to infrastructure, educators' digital competence is an important factor that also influences the quality of technology implementation in learning (Prinanda, 2025). BPS data on education highlights that although many educators have high levels of education and use technology, access to certified digital training and equitable distribution of competencies across regions remain issues that need attention. Previous research has largely examined the perceptions of students and teachers regarding technology use, the effectiveness of digital media in improving learning outcomes, or the evaluation of specific platform usage such as LMS (Yana & Adam, 2019). However, studies that comprehensively analyze technology-based education policies, starting from policy direction, infrastructure support, teacher readiness, and the link to implementation realities in various regional contexts across Indonesia, are still relatively limited (Hardiman et al., 2025). This is important because strong education policies require not only strategic formulation but also consistent implementation in the field, considering geographical context, infrastructure, and teacher competence (Darmawati et al., 2025). Thus, this article aims to systematically explore and explain the development of technology-based education policies and how these policies are implemented within the national education system, including the main

challenges and opportunities that exist. This approach is expected to provide a more holistic policy overview and relevant strategic recommendations for policymakers, educators, and education stakeholders in Indonesia's digital era.

2. Methodology

Research Design

This study employed a mixed methods research design that integrated quantitative and qualitative approaches to obtain a comprehensive understanding of the development and implementation of technology-based education policies in Indonesia (Doyle et al., 2009). The quantitative approach was utilized to measure the level of policy readiness and implementation across educational institutions, while the qualitative approach was used to explore contextual factors, stakeholder experiences, and policy implementation dynamics that could not be fully captured through numerical data. The study was conducted from March to August 2025 in several representative regions, including urban, rural, and 3T (remote, outermost, and underdeveloped) areas, to reflect the diversity of educational conditions across Indonesia.

Population and Sample

The study population consisted of key stakeholders within the Indonesian education system, including officials from provincial, district, and municipal education offices, school principals, teachers, education policy developers, and students. For the quantitative component, a total of 600 respondents comprising teachers and school principals were selected using stratified random sampling based on educational level (elementary, junior high, and senior high school) and regional characteristics. This sampling strategy enabled comparative analysis across educational levels and geographical contexts. For the qualitative component, purposive sampling was employed to select 25 key informants, including policymakers, education office representatives, school principals, and educational experts. These informants were chosen based on their involvement and experience in implementing technology-based education policies, thereby providing in-depth and contextual insights into the policy implementation process.

Instrument

Three primary instruments were used in this study. First, a structured questionnaire using a five-point Likert scale was developed to measure four major constructs: technology infrastructure readiness, educators' digital competence, institutional policy support, and technology-based education policy implementation. Prior to data collection, the questionnaire was subjected to a pilot test to assess its validity and reliability. Second, semi-structured interview guidelines were developed to facilitate in-depth exploration of stakeholders' experiences, perceptions, and challenges related to policy implementation. Third, a documentation checklist was used to analyze policy documents, government reports, and educational statistical

records relevant to educational technology development. Instrument validity was established through expert judgment involving specialists in educational policy and educational technology. Reliability testing was conducted using Cronbach's Alpha, with all constructs achieving coefficients above the acceptable threshold of 0.70.

Data Collection

Data were collected through multiple techniques to ensure methodological triangulation. Quantitative data were gathered through online and offline surveys administered to teachers and school principals across the selected regions. Qualitative data were obtained through semi-structured interviews and Focus Group Discussions (FGDs) involving teachers, school leaders, policymakers, and educational experts. In addition, secondary data were collected from policy documents, Ministry of Education reports, Statistics Indonesia (BPS) publications, and the Basic Education Data System (Dapodik). The combination of primary and secondary data sources enabled a more comprehensive assessment of policy development and implementation.

Data Analysis

Quantitative data were analyzed using descriptive statistics to examine respondent characteristics and the overall level of policy implementation. Exploratory Factor Analysis (EFA) was performed to identify the underlying dimensions of technology-based education policy readiness. Subsequently, Structural Equation Modeling (SEM) was employed to examine the relationships among infrastructure readiness, educators' digital competence, institutional policy support, and policy implementation outcomes. To investigate differences across educational levels and geographical regions, Multilevel Modeling (MLM) was applied, considering the hierarchical structure of the data. Qualitative data obtained from interviews and FGDs were analyzed using thematic analysis and content analysis techniques. Finally, findings from both quantitative and qualitative strands were integrated during interpretation to provide a comprehensive explanation of technology-based education policy implementation in Indonesia. The trustworthiness of the study was ensured through expert validation, reliability testing using Cronbach's Alpha, data triangulation, and methodological triangulation (Plano Clark, 2017).

3. Results and Discussion

The implementation of technology-based education policy in Indonesia has been carried out through a series of government initiatives aimed at accelerating the digitalization of the national education system. These initiatives include the development of digital learning platforms such as the Learning Management System (LMS), the strengthening of digital literacy programs for educators, and the provision of digital devices and internet infrastructure to educational units, particularly in rural and 3T (remote, outermost, and underdeveloped) regions. At the policy level, the Merdeka Curriculum introduced by the Ministry of Education, Culture, Research, and Technology serves as a key framework encouraging schools

to integrate digital technology into their instructional practices. However, the extent to which these policies are effectively implemented varies considerably across regions and educational levels, reflecting disparities in infrastructure readiness, educators' digital competence, and institutional support. The following sections present the findings of this study, beginning with respondent characteristics, followed by an analysis of infrastructure readiness, determinants of policy implementation, structural relationships among key variables, and contextual differences across regions and educational levels.

Respondent Characteristics

The study involved 600 respondents, including teachers and school principals, drawn proportionally from three educational levels and three regional contexts, yielding a sample that robustly represents the diversity of Indonesia's education system. Table 1 presents the demographic characteristics of respondents. The distribution of participants across different regions and educational levels provides a comprehensive perspective on the implementation conditions and challenges experienced by schools. This composition strengthens the reliability of the findings by capturing variations in institutional capacity, technological readiness, and contextual factors influencing educational policy implementation.

Table 1. Demographic Characteristics of Respondents (n = 600)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	278	46.3
	Female	322	53.7
School Level	Elementary School	215	35.8
	Junior High School	193	32.2
	Senior High School	192	32.0
Region	Urban	220	36.7
	Rural	250	41.7
	3T Areas	130	21.6

Table 1 shows that the respondents were relatively balanced in terms of gender distribution, with female respondents (53.7%) slightly outnumbering male respondents (46.3%). This balanced composition provides a representative perspective regarding the implementation of technology-based education policies from both male and female educators and school leaders. Based on educational level, elementary school respondents constituted the largest proportion (35.8%), followed by junior high school respondents (32.2%) and senior high school respondents (32.0%). The relatively balanced distribution across educational levels allows for a comprehensive examination of policy implementation in different educational contexts. In terms of geographical distribution, the majority of respondents were drawn from rural areas (41.7%), followed by urban areas (36.7%) and 3T regions (21.6%). This distribution was intentionally designed to capture variations in infrastructure readiness, digital competence, and institutional support across different regional contexts. The inclusion of respondents from 3T regions is particularly important because these areas often face greater challenges related to internet connectivity, digital device availability, and access to educational

technology. Overall, the respondent distribution indicates that the study adequately represents diverse educational and geographical settings in Indonesia, thereby providing a robust basis for analyzing variations in the implementation of technology-based education policies across regions and educational levels.

Infrastructure Readiness Across Regions

This study reveals a substantial infrastructure gap between urban and 3T regions: urban schools report stable internet access at 82%, compared to only 38% in 3T areas, a disparity of 44 percentage points that fundamentally constrains equitable policy implementation. Similarly, digital device availability stands at 79% in urban areas versus 35% in 3T regions, and digital competence confidence at 70% versus 32%. Table 2 presents the full comparison of key infrastructure indicators across regions. These disparities demonstrate that geographical inequality remains a critical barrier in achieving inclusive digital transformation within the education sector. The findings further suggest that targeted interventions are required to ensure that technological development reaches schools in remote and underserved areas.

Table 2. Infrastructure Readiness and Technology Utilization by Region

Indicator	Urban (%)	Rural (%)	3T Areas (%)
Stable Internet Access	82	61	38
Availability of Digital Devices	79	57	35
Regular Technology Use	76	54	39
Digital Competence Confidence	70	55	32

The results show that schools located in urban areas demonstrate considerably higher levels of technological readiness than schools in rural and 3T regions. Approximately 82% of respondents from urban areas reported stable internet access, compared to 61% in rural areas and only 38% in 3T regions. Similar patterns were observed regarding the availability of digital devices and the regular use of technology in teaching and learning activities.These findings indicate that infrastructure readiness remains uneven across geographical regions. The substantial gap between urban and 3T areas suggests that access to digital resources continues to be a major challenge for achieving equitable implementation of technology-based education policies. Although national policies promoting educational digitalization have been implemented widely, the capacity of schools to adopt technology effectively is strongly influenced by local infrastructure conditions.

The qualitative findings further support these results. Informants from rural and 3T regions consistently reported unstable internet connectivity, limited access to digital devices, and insufficient technical support as major barriers to technology integration. Several participants explained that internet disruptions frequently interrupted online learning activities and reduced the effectiveness of digital learning platforms. In contrast, respondents from urban schools reported fewer technical constraints and greater opportunities to integrate technology into daily instructional practices. The integration of quantitative and qualitative findings

demonstrates that infrastructure readiness is a foundational requirement for successful technology-based education policy implementation. Without adequate internet connectivity, digital devices, and technical support systems, schools face difficulties in utilizing educational technology effectively, regardless of policy availability. These findings reinforce previous studies highlighting that unequal access to digital infrastructure remains one of the primary factors contributing to the educational digital divide and limiting the effectiveness of technology-driven educational reforms.

Determinants of Technology-Based Education Policy Implementation

Exploratory Factor Analysis (EFA) identifies three principal determinants of technology-based education policy implementation: infrastructure readiness, educators' digital competence, and institutional policy support, with all factor loadings exceeding 0.78 and overall sampling adequacy confirmed by KMO = 0.891 (Bartlett's $p < 0.001$). These three factors collectively explain the variance in policy implementation readiness and confirm that no single dimension is sufficient on its own.

Table 3. Exploratory Factor Analysis Results

Variable	Factor Loading
Internet Availability	0.842
Digital Device Availability	0.817
LMS Accessibility	0.791
Digital Teaching Skills	0.865
Digital Assessment Skills	0.834
School Policy Support	0.781
Professional Development Support	0.809

KMO = 0.891
Bartlett's Test of Sphericity = $p < 0.001$

The EFA results indicate that infrastructure readiness constitutes the first major factor influencing policy implementation. High factor loadings for internet availability (0.842) and digital device availability (0.817) suggest that technological infrastructure plays a fundamental role in supporting educational digitalization. These findings imply that schools with better access to technological resources are more likely to implement technology-based education policies effectively.The second factor identified is educators' digital competence. Digital teaching skills (0.865) and digital assessment skills (0.834) emerged as the strongest indicators within this dimension. This finding demonstrates that the success of technology integration depends not only on infrastructure availability but also on teachers' ability to utilize digital tools for pedagogical purposes. Schools with higher levels of teacher digital competence tend to exhibit more effective implementation of technology-enhanced learning practices. This is supported by Rini & Lestari (2025), who found that principal leadership strategies focused on strengthening digital competencies directly contributed to enhanced teacher professionalism and more effective technology integration in schools (Rini & Lestari, 2025).

The third factor relates to institutional policy support. The relatively high factor loadings for school policy support (0.781) and professional development support

(0.809) indicate that organizational commitment and continuous capacity-building initiatives significantly contribute to implementation readiness. These results suggest that institutional support functions as an enabling mechanism that facilitates both infrastructure utilization and the development of educators' digital competence This finding is reinforced by Basuki et al., (2025), who demonstrated that principal leadership in teacher development plays a significant role in strengthening educators' capacity and readiness to implement school programs, including technology-based initiatives (Basuki et al., 2025).

The qualitative findings provide further explanation for these quantitative results. Interview participants consistently emphasized that adequate infrastructure alone does not guarantee successful implementation. Several school principals reported that technology investments produced limited outcomes when teachers lacked sufficient digital pedagogical skills. Likewise, teachers highlighted the importance of continuous training programs and managerial support in improving their confidence and ability to integrate technology into classroom instruction.The convergence of quantitative and qualitative findings indicates that technology-based education policy implementation is shaped by the interaction of technological, human resource, and institutional factors. These findings support the view that digital transformation in education requires a comprehensive ecosystem in which infrastructure readiness, educators' competence, and institutional support operate simultaneously to achieve sustainable implementation outcomes. Such results are consistent with previous studies emphasizing organizational readiness and human capacity as critical determinants of educational technology adoption.

Structural Relationships Among Variables

Structural Equation Modeling (SEM) confirms that infrastructure readiness is the strongest direct predictor of policy implementation ($\beta = 0.48$, $p < 0.001$), followed by educators' digital competence ($\beta = 0.37$, $p < 0.001$) and institutional policy support ($\beta = 0.31$, $p < 0.001$). The overall model demonstrates good fit (CFI = 0.943, TLI = 0.931, RMSEA = 0.054), indicating that the proposed structural framework adequately explains the relationships among variables. These findings establish that all three factors make independent and statistically significant contributions to implementation outcomes. Furthermore, the results highlight that successful policy implementation requires the integration of technological capacity, human resources, and organizational commitment. Therefore, strengthening infrastructure, enhancing teachers' digital skills, and improving institutional support mechanisms are essential strategies for achieving sustainable educational transformation.

Table 4. Goodness-of-Fit Indices of the SEM Model

Fit Index	Recommended Value	Obtained Value
CFI	≥ 0.90	0.943
TLI	≥ 0.90	0.931
RMSEA	≤ 0.08	0.054
SRMR	≤ 0.08	0.046
χ^2/df	< 3.00	2.17

The SEM results indicate that the proposed model achieved a satisfactory level of goodness-of-fit. The Comparative Fit Index (CFI = 0.943) and Tucker-Lewis Index (TLI = 0.931) exceeded the recommended threshold of 0.90, suggesting that the model adequately explains the observed relationships among variables. Furthermore, the RMSEA value of 0.054 and SRMR value of 0.046 indicate a low level of approximation error, demonstrating that the model represents the empirical data well.To further examine the structural relationships among variables, path coefficient analysis was conducted as presented in Table 5.

Table 5. Structural Path Coefficients

Path	Standardized Coefficient (β)	p-value
Infrastructure Readiness → Policy Implementation	0.48	<0.001
Digital Competence → Policy Implementation	0.37	<0.001
Institutional Support → Digital Competence	0.42	<0.001
Institutional Support → Policy Implementation	0.31	<0.001

The results show that infrastructure readiness has the strongest direct influence on technology-based education policy implementation ($\beta = 0.48$, $p < 0.001$). This finding indicates that schools with adequate internet access, digital devices, and technological facilities are more likely to implement technology-based education policies effectively.Educators' digital competence also significantly influences policy implementation ($\beta = 0.37$, $p < 0.001$). This suggests that technological infrastructure alone is insufficient without teachers possessing the necessary skills to integrate technology into instructional practices. Teachers who demonstrate stronger digital competencies are more capable of utilizing educational technologies to support learning activities.

Institutional policy support was found to significantly influence both educators' digital competence ($\beta = 0.42$, $p < 0.001$) and policy implementation ($\beta = 0.31$, $p < 0.001$). These findings imply that supportive institutional environments, including professional development opportunities, managerial commitment, and policy guidance, play an essential role in strengthening technology adoption within schools.The qualitative findings provide additional support for these results. Interview participants consistently emphasized that schools receiving continuous training, technical assistance, and administrative support were more successful in implementing digital learning initiatives. Several school principals reported that investments in technology infrastructure produced limited outcomes when not accompanied by teacher capacity-building programs. Similarly, teachers highlighted that institutional encouragement and ongoing professional development significantly increased their confidence in integrating technology into classroom instruction.The integration of quantitative and qualitative findings demonstrates that technology-based education policy implementation is not determined by a single factor but rather by the interaction among infrastructure readiness, educators' digital competence, and institutional policy support. These findings suggest that effective educational digital transformation requires simultaneous investment in technological resources, human capacity development, and organizational support systems.

Regional and Educational Level Differences

Multilevel modeling results confirm that regional context and educational level are significant determinants of implementation outcomes. Urban schools achieve substantially higher implementation scores ($\beta = 0.64$, $p < 0.001$) than rural schools ($\beta = 0.31$, $p = 0.012$), while senior high schools outperform elementary schools ($\beta = 0.53$, $p < 0.001$). These findings indicate that a uniform national policy approach is insufficient to address the diverse conditions across Indonesia's educational landscape. Differences in infrastructure availability, teacher competency, digital accessibility, and institutional support contribute to variations in implementation effectiveness. Therefore, context-sensitive strategies and differentiated interventions are needed to ensure equitable policy implementation across regions and educational levels.

Table 6. Multilevel Modeling Results

Predictor	Coefficient	Standard Error	p-value
Urban Region	0.64	0.08	<0.001
Rural Region	0.31	0.10	0.012
Junior High School	0.42	0.07	<0.001
Senior High School	0.53	0.06	<0.001

The multilevel modeling results indicate that both regional context and educational level significantly influence the implementation of technology-based education policies. Schools located in urban areas demonstrated significantly higher levels of policy implementation compared to schools in rural and 3T regions. The positive coefficient for urban regions ($\beta = 0.64$, $p < 0.001$) suggests that favorable infrastructure conditions, greater access to technological resources, and stronger institutional support contribute to more effective implementation outcomes.Regional disparities were also evident in rural and 3T areas, where limited infrastructure and technological resources continue to constrain policy implementation. Although rural schools have shown progress in technology adoption, the lower coefficient values indicate that implementation remains less optimal compared to urban settings. These findings suggest that geographical context remains a critical determinant of educational digital transformation in Indonesia.

The analysis further revealed significant differences across educational levels. Junior high schools ($\beta = 0.42$, $p < 0.001$) and senior high schools ($\beta = 0.53$, $p < 0.001$) exhibited higher levels of technology utilization compared to elementary schools. This finding indicates that technology integration tends to be more intensive at higher educational levels, particularly in the use of Learning Management Systems (LMS), digital assessment tools, and project-based learning activities. This is consistent with Sundari et al. (2025), who found that project-based learning design at the senior high school level effectively supports the development of students' creative thinking skills and independent learning, both of which are facilitated by stronger digital technology integration (Sundari et al., 2025).

The qualitative findings provide additional insights into these quantitative results. Teachers and school principals reported that secondary-level students generally

possess higher levels of digital literacy, technological familiarity, and learning autonomy, making technology integration more feasible and effective. In contrast, elementary school teachers emphasized the need for closer supervision, age-appropriate digital content, and greater parental involvement when implementing technology-based learning activities.Informants from rural and 3T regions also highlighted persistent challenges related to internet connectivity, limited access to digital devices, and inadequate technical support. Several participants noted that even when digital learning platforms were available, unstable internet connections often restricted their effective use. These challenges partly explain the lower implementation outcomes observed in disadvantaged regions (O'Dwyer et al., 2004).

The integration of quantitative and qualitative findings demonstrates that technology-based education policy implementation is strongly shaped by contextual factors. Regional disparities and educational-level differences influence not only access to technology but also the capacity of schools and teachers to utilize technology effectively. Therefore, policy interventions should adopt differentiated strategies that consider local conditions, infrastructure availability, and the specific pedagogical needs of each educational level. Such an approach would contribute to more equitable and sustainable implementation of technology-based education policies across Indonesia.

Integrated Discussion

The central finding of this study is that no single factor determines the success of technology-based education policy implementation in Indonesia. Rather, infrastructure readiness, educators' digital competence, and institutional policy support must operate simultaneously and in alignment. This convergent finding, supported by both quantitative modeling (EFA, SEM, MLM) and qualitative evidence from interviews and FGDs, reveals that policies concentrating on infrastructure alone, or on training alone, produce limited and unsustainable outcomes.The EFA results identified three key dimensions underlying implementation readiness, while the SEM analysis confirmed significant relationships among infrastructure readiness, digital competence, and institutional support. These findings suggest that technology-based education policies cannot be effectively implemented through infrastructure provision alone. Rather, successful implementation requires simultaneous investments in human resource development and institutional capacity building.

The multilevel modeling results further demonstrated that regional characteristics and educational levels significantly influence implementation outcomes. Schools in urban areas and secondary education levels exhibited higher levels of technology utilization than schools in rural, 3T, and elementary education settings. These differences indicate that a uniform policy approach may be insufficient to address the diverse conditions of Indonesian educational institutions. The qualitative findings complement the quantitative evidence by explaining how limited digital pedagogical competence, inadequate technical assistance, and unequal infrastructure distribution constrain policy implementation in practice. The

integration of quantitative and qualitative findings highlights the importance of adopting a comprehensive ecosystem approach to educational digital transformation.

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Overall, the findings support digital transformation and organizational readiness perspectives, which emphasize that successful technology adoption depends on the alignment of technological resources, human competencies, and institutional support systems. The evidence further indicates that effective digital transformation is not merely determined by the availability of technology, but also by the capacity of educational institutions to manage change and develop adaptive practices. Therefore, future policy initiatives should prioritize equitable infrastructure development, continuous professional development programs, and context-sensitive implementation strategies to reduce regional disparities. These efforts are essential to strengthen the sustainability of technology-based education policies and ensure that digital innovation contributes to improving educational quality across Indonesia.

4. Conclusion

This research concludes that technology-based education policies in Indonesia have experienced significant development and are widely implemented in various educational units. However, the quality and level of implementation still show considerable variation across regions and educational levels. Schools in urban areas tend to have better infrastructure readiness and digital competence of educators compared to schools in rural areas and 3T regions, resulting in more optimal policy implementation.

The analysis results indicate that the readiness to implement technology-based education policies is influenced by three main factors: technological infrastructure readiness, educators' digital competence, and institutional policy support. Policy support plays a crucial role in enhancing educators' digital competencies, which in turn has a positive impact on the quality of policy implementation in teaching practice. This finding confirms that policy success is not only determined by the availability of technology, but also by strengthening human resource capacity and support systems at the institutional level.

The integration of quantitative and qualitative findings reveals that the main challenges to implementing technology-based education policies lie in infrastructure gaps, limited digital pedagogical training, and differences in geographical context and the characteristics of different educational levels. Therefore, technology-based education policies need to be directed not only toward expanding access and technology adoption, but also toward strengthening educators' digital pedagogical competencies and formulating policy strategies that are more contextual, adaptive, and equitable across regions.

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