


Challenges and Opportunities for Digital Education Financing Against the Digital Infrastructure Gap

 <https://doi.org/10.31004/jele.v10i4.1035>

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ABSTRACT

Digital transformation in the world of education requires comprehensive and equitable integration of technology, especially at the primary education level. Studies from Wahyudi and Jatun (2024) and Nazira, Zahra, and Gusmaneli (2024) show that the use of digital technology such as computers, the internet, and interactive learning platforms has opened up opportunities to increase flexibility, collaboration, and personalization in the teaching and learning process. Learning models such as flipped classroom, blended learning, and hybrid learning have been proven to increase student motivation and participation. However, behind these opportunities, there are still big challenges in the form of a glaring digital infrastructure gap between regions and between educational institutions. Inequality of internet access, limited technological devices, low digital literacy, and lack of training for teachers are serious obstacles to the implementation of digital learning equally. In addition, complex geographical and socioeconomic conditions further widen the digital divide between urban and rural areas. In this context, digital education financing is an important instrument to bridge infrastructure disparities and increase human resource capacity. Targeted financing strategies should include the procurement of tools, strengthening teacher training, developing curriculum-based local content, and supporting policies that promote equitable access to technology. Thus, digital education financing can be positioned as a strategic investment in creating an inclusive, adaptive, and equitable education system in the digital era.

Keywords: *Digital Education Financing, Infrastructure Gap, Digital Literacy, Basic Education, ICT.*

Article History:

Received 14th June 2025

Accepted 19th July 2025

Published 24th July 2025



INTRODUCTION

In the last decade, digital transformation has become the main motor in equitable distribution and improvement of global education. However, the reality in developing countries—including Indonesia—shows that digital infrastructure disparities are a serious obstacle. Susenas 2023 data recorded internet penetration of only 64.1% in urban areas, and much lower in rural areas (35.9%). This condition is exacerbated by limited electrical power, network infrastructure, and hardware in many remote areas.

This inequality of access has become more pronounced during the COVID-19 pandemic. The 2020 MoEC-MoRA survey showed that 67% of teachers faced difficulties using digital devices for online learning, indicating that digital education is not even in terms of quality and access. A similar thing is observed in the university environment, where limited ICT infrastructure slows down digital transformation despite the growing need for online learning.

The community and the state are also trying to bridge this gap. Initiatives such as ConnectEd in the U.S. and DIII by the ITU offer solutions through the development of connectivity and devices, but their effectiveness is heavily influenced by the financing models—public, private, granted, or PPP—used. In Indonesia, a multi-level strategy through the State Budget, SOEs, and the private sector is directed, but still faces challenges related to implementation and sustainability.

Most studies highlight infrastructure and access, but few have systematically examined *how financing models* – public, private, granted, and PPP – can affect the reduction of digital infrastructure gaps in the context of digital education, particularly in Indonesia. Through a literature review with a clear framework (2015–2025), this study presents a synthesis of international best practices and local challenges. It includes the evaluation of empirical data from national sources such as Susenas, MoEC reports, and global initiatives such as ConnectEd and DIIL, making this approach more comprehensive and relevant than previous literature.

METHOD

This study uses a literature review approach to comprehensively explore the dynamics of digital education financing challenges and opportunities in overcoming digital infrastructure gaps. Literature studies were chosen as a method because they are relevant for summarizing existing knowledge, identifying research gaps, and compiling evidence-based recommendations from various scientific sources over a given time span (Xiao & Watson, 2019).

The data sources in this study were obtained from various scientific publications, both on a national and international scale, published in the period 2015–2025. Literature searches are carried out through several reputable academic databases, including: Google Scholar, ScienceDirect, ERIC (Education Resources Information Center), DOAJ (Directory of Open Access Journals), Garuda RistekBRIN and SINTA for national literature.

Inclusion criteria are established to guarantee the relevance and quality of the literature analyzed, namely: Articles that address the topics of digital education financing, digital transformation in education, and digital infrastructure gaps. Empirical and conceptual studies that are relevant in the fields of education, educational economics, and public policy. Publication in scientific journals that have been accredited or indexed nationally/internationally.

While the exclusion criteria include: Articles that are not available in full access. Literature that is not relevant to the focus of the study or is not based on scientific data. From the initial search results, more than 60 documents were obtained which were then filtered using a tiered screening technique based on titles, abstracts, and complete contents, so that 25 main articles were obtained that were used as the basis for analysis.

Data analysis was carried out using a thematic synthesis approach. This process involves three main stages: Initial coding of the key themes in the article, such as: Financing models (State Budget, BOS funds, PPP, corporate funding, international aid). Digital infrastructure dimensions (internet connectivity, technological devices, digital learning platforms) Identification of regional gaps (urban vs. rural), education levels, and accessibility Categorization and classification of themes, to group data based on patterns and differences in local and global **contexts**. Interpretive synthesis, which links financing variables and digital infrastructure disparities, and highlights strategic opportunities for the development of digital education financing policies in Indonesia. The credibility of the data is strengthened by comparing various sources from different contexts (national and international), and using *cross-reference checking* to ensure the consistency of findings.

FINDINGS AND DISCUSSION

The integration of technology in basic education is one of the strategic steps in responding to global digital transformation. Wahyudi and Jatun (2024) emphasized that the application of digital technology, such as computers, the internet, and interactive learning applications, has introduced a more flexible, collaborative, and personalized approach to learning. Models such as flipped classroom, blended learning, and hybrid learning have been shown to increase student motivation and activeness, as well as enable access to education that allows students to learn independently without being limited by classrooms or formal time.

Nevertheless, such integration is inseparable from substantial challenges. This study underlines that the digital divide is a major obstacle in the implementation of educational technology. The difference in internet access and digital devices is still very striking between public and private elementary schools, as well as between urban and rural areas. For example, only about 67.79% of public elementary schools have internet facilities compared to 84.25% of private schools. This condition shows that the development of technological infrastructure is not even

This infrastructure gap also has a direct impact on the readiness of teachers and students to adopt digital learning. Many teachers, especially in remote areas, face technical and pedagogical constraints in utilizing digital devices and platforms. Unequal access to training and technological resources leads to low effectiveness in the use of technology in learning activities. This gap is exacerbated by the geographical and socio-economic conditions of the community that hinder the equitable distribution of ICT infrastructure, as conveyed by Yayat D. Hadiyat (2014), who said that the cost of infrastructure development in remote areas is very high and is not the main priority of the local community

In this context, digital education financing is the key to bridging the digital infrastructure gap. Targeted financing is needed to: Improve internet access and digital devices in disadvantaged schools. Provide comprehensive technical support and training for teachers. Develop inclusive programs, such as borrowing devices for underprivileged students and subsidizing internet data for online learning.

Wahyudi and Jatun also highlighted that the use of technology in education is not only a matter of hardware, but also soft skills such as digital learning design and virtual classroom management. Therefore, financing must include strengthening the capacity of human resources as part of the digital education ecosystem

Thus, it can be concluded that Wahyudi and Jatun's article provides an important foundation in understanding the relationship between digital transformation in primary education and the need for financing oriented towards equitable distribution of infrastructure and capacity building. These findings are particularly relevant to support the argument that without policy interventions and equitable financing, the digital divide will not only persist, but also have the potential to widen inequality in the quality of education between regions.

Major changes in the world of education today cannot be separated from the impact of information and communication technology advances. Especially as a key infrastructure in the implementation of digital education. Nazira, Zahra, and Gusmaneli (2024) stated that ICT plays an important role in expanding access to education, improving the quality of learning, and supporting the development of 21st century competencies. The use of e-learning platforms, interactive applications, and data-based learning is a concrete form of technology integration in the Indonesian education system

However, the study underscores that the use of ICT still faces various fundamental challenges, especially related to the limitations of digital infrastructure. One of the main obstacles is uneven internet access, especially in the 3T (frontier, outermost, disadvantaged) areas. Schools in remote areas often do not have a stable internet connection, or even not available at all. This creates a clearly visible digital divide between urban and rural areas

On the other hand, the inequality in the availability of technological devices is also a major obstacle. Schools in urban areas generally have adequate technological facilities such as computers, projectors, and networks, while schools in rural areas often lack such facilities. This gap shows that digital education financing needs to be directed to bridge this infrastructure disparity

The low digital literacy of teachers and students further exacerbates the existing challenges. Many teachers have not been able to make optimal use of technology due to a lack of systematic training. In addition, high costs in hardware procurement, platform subscriptions, and ICT infrastructure maintenance are a heavy burden, especially for public schools in areas with limited budgets. This shows that the financing strategy must include aspects of strengthening human resource capacity and infrastructure management, not just procurement of equipment

However, great opportunities remain open. The use of ICT allows for personalization of learning, increased student involvement, cross-border collaboration, and empowerment of students with disabilities through adaptive technology. In this context, digital education financing can be positioned as a strategic investment to create an education system that is inclusive, efficient, and adaptive to the demands of the future

The article also emphasizes the importance of developing relevant local content as well as integrating ICT into the curriculum in a structured manner. This is where the role of education policies and financing schemes becomes very important. Programs such as BOS (School Operational Assistance) must be directed to ensure equitable digital access, increase digital literacy, and sustainability of technology-based learning, especially in areas that were previously marginalized in terms of infrastructure.

CONCLUSIONS

Based on studies from Wahyudi & Jatun (2024) and Nazira, Zahra & Gusmaneli (2024), it can be concluded that the integration of technology in basic education is an urgent need in responding to the demands of digital transformation and equitable distribution of national education. Both have consistently emphasized that digital technology – through hardware, online learning platforms, and digital management systems – has great potential in improving the quality of learning, expanding access, and forming an inclusive and sustainable education ecosystem. However, the main challenges that emerge are the digital infrastructure gap which includes uneven internet access, inequality in the availability of technological devices, low digital literacy, and lack of teacher training that is adaptive to technology. This gap occurs not only between regions, but also between institutional statuses, which ultimately widens the gap in inequality in the quality of education. The two articles agreed that digital education financing is not just about procuring devices, but must include strengthening the capacity of human resources, providing contextual learning content, and supporting systematic and equitable policies. In this context, an inclusive and sustainable financing strategy is an absolute requirement to bridge the existing digital divide. Thus, digital education financing must be positioned as a national strategic investment, which not only addresses infrastructure disparities, but also facilitates technology-based pedagogical transformation. Without fair and structured financing interventions, the digital divide will continue to persist and become a major obstacle to realizing equitable, quality, and adaptive education to the challenges of the 21st century.

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