

Barriers to Effective Digital Learning Implementation in Madagascar

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ABSTRACT

This study aims to examine the key barriers to the effective implementation of digital learning in Madagascar by identifying the structural, institutional, pedagogical, and socio-economic factors that shape digital education practices within a low-income, capacity-constrained education system. The study adopts a qualitative descriptive research design using an interpretive approach. Data are drawn from peer-reviewed academic literature, empirical studies on digital learning and higher education in Madagascar, and comparative evidence from developing and post-crisis education contexts. The analysis applies a thematic analytical technique, involving systematic coding, categorization, and synthesis of recurring patterns related to infrastructure, governance, teacher capacity, access inequality, and technology adoption mechanisms. The findings reveal that the implementation of digital learning in Madagascar is constrained by interconnected barriers, including inadequate digital and physical infrastructure, limited institutional and governance capacity, insufficient teacher digital competence, and persistent socio-economic inequality that affects access and participation. Advanced technologies such as artificial intelligence offer potential benefits, yet their effectiveness remains limited by unresolved foundational conditions, and their adoption could exacerbate existing disparities if implemented prematurely. This study contributes original value by providing a context-sensitive and integrative analysis of digital learning barriers in Madagascar, moving beyond technology-centered explanations. By linking digital transformation theory with empirical evidence from a structurally constrained education system, the study offers practical insights for policy design and institutional reform. It enriches the literature on the implementation of digital education in low-income and developing contexts.

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INTRODUCTION

Digital learning has become a central feature of contemporary educational reform agendas across the globe, reflecting broader processes of digital transformation in public institutions and knowledge systems. Advances in information and communication technologies, learning management systems, and artificial intelligence have reshaped how teaching, learning, and academic administration are conceptualized and practiced (Vial, 2019; Anwar et al., 2021). In many contexts, digital learning is promoted as a mechanism to expand access, enhance instructional quality, increase system resilience, and respond to disruptions caused by crises such as pandemics, conflicts, or economic instability (Utsumi, 2022). These expectations have encouraged governments and universities in developing countries to adopt digital education strategies, often supported by international development partners. The effectiveness of such initiatives, particularly in structurally constrained environments, remains uneven and inadequately understood.

In low-income countries, the implementation of digital learning is shaped by complex interactions among technological availability, institutional capacity, human capital, and socio-economic conditions. A

study on digital transformation emphasizes that technology adoption alone does not constitute meaningful transformation, as organizational readiness, governance structures, and cultural practices significantly influence outcomes (Vial, 2019). Educational systems that lack stable infrastructure, adequate funding, and skilled personnel often struggle to integrate digital tools into pedagogical practice in ways that produce sustained learning benefits. Empirical studies demonstrate that limited access to electricity, unreliable internet connectivity, and inadequate physical learning environments directly undermine the potential of digital education initiatives (Male & Burden, 2013; Andrade et al., 2024). These constraints are particularly salient in sub-Saharan African contexts, where digital divides intersect with long-standing educational inequalities.

Madagascar provides a critical case for examining barriers to effective digital learning implementation. The country's education system faces persistent challenges related to infrastructure deficits, institutional fragility, and limited human resource capacity, especially within higher education. Previous study identifies systemic weaknesses in governance, financing, and academic support structures that constrain institutional effectiveness and innovation (Emynorane et al., 2025; Espinosa et al., 2024). Digital learning initiatives in Madagascar have often been introduced as policy responses to access and quality concerns, yet their implementation has been fragmented and uneven across institutions and regions. The gap between policy aspirations and operational realities highlights the need for a deeper analysis of contextual barriers that shape digital learning outcomes.

Existing literature on educational technology adoption underscores the importance of aligning digital tools with pedagogical practices and curriculum design. Studies on outcome-based education and student-centered learning in developing contexts reveal that technology integration frequently occurs without adequate instructional redesign, resulting in limited pedagogical impact (Katawazai, 2021). A study of English-medium instruction reforms similarly shows that educational innovations imposed without sufficient teacher preparation and contextual adaptation generate resistance and uneven learning experiences (Jiang et al., 2019). These findings suggest that the effectiveness of digital learning depends not only on access to technology but also on teachers' professional competence and institutional support mechanisms.

Teacher capacity emerges as a critical factor in the implementation of digital learning. Studies across diverse education systems demonstrate that educators often lack sufficient training in digital pedagogy, instructional design, and technology-mediated assessment (Mazi & Yıldırım, 2025). In contexts where professional development systems are weak, teachers may rely on traditional instructional methods even when digital platforms are available. A study on teacher professionalism in private high schools indicates that limited institutional support and inadequate training opportunities constrain teachers' ability to adapt to educational change (Emynorane et al., 2024; Boretti, 2025). These challenges are amplified in digital learning environments that require new competencies related to online facilitation, student engagement, and digital assessment.

Socio-economic inequality further complicates the implementation of digital learning. Studies on technology access in schools highlight that digital initiatives often reproduce or intensify existing disparities between urban and rural areas and between socio-economic groups (Salminen et al., 2020). Students from low-income households face barriers related to device ownership, connectivity costs, and the availability of conducive learning spaces at home. A study on educational access in fragile and conflict-affected contexts demonstrates that community resilience and household resources significantly influence students' ability to benefit from alternative learning modalities (Utsumi, 2022). In Madagascar, where poverty rates remain high and infrastructure development is uneven, these factors pose substantial obstacles to inclusive digital education.

Recent scholarships increasingly emphasize the role of artificial intelligence in shaping the future of digital learning. Systematic reviews indicate that AI applications can enhance personalization, learning analytics, and academic performance in open and distance learning environments (Adewale et al., 2024). Frameworks for AI-driven education propose models that integrate intelligent tutoring systems, adaptive

learning pathways, and automated assessment tools (Bagherimajd & Khajedad, 2025). Open-source platforms and AI assistants embedded in learning management systems demonstrate technical feasibility and pedagogical potential in well-resourced institutions (Alier et al., 2025). Cross-national evidence suggests that AI adoption can contribute to human capital development when supported by strong institutional foundations and policy coherence (Tian & Zhang, 2025).

At the same time, an emerging study cautions against the uncritical adoption of advanced technologies in contexts lacking basic digital readiness. Studies of AI implementation in higher education reveal significant gaps in user knowledge, institutional preparedness, and ethical governance frameworks (Boaro et al., 2025). Evidence from Botswana shows that student perceptions of AI tools such as ChatGPT are shaped by access, digital literacy, and institutional guidance, highlighting the importance of contextual adaptation (Indrawati et al., 2025). These findings are relevant to Madagascar, where foundational challenges in infrastructure, governance, and human capital may limit the effective and equitable use of AI-driven learning systems.

The relationship between physical educational spaces and learning outcomes also remains central to discussions of digital education. An empirical study demonstrates that the quality of school infrastructure, including classroom design, electricity access, and learning resources, significantly affects student engagement and achievement (Andrade et al., 2024). Digital learning initiatives that overlook these material conditions risk becoming symbolic rather than functional reforms. This perspective aligns with broader critiques of technology-centered development narratives that prioritize innovation over structural investment.

Comparative studies from other developing and post-crisis contexts provide valuable insights into the challenges facing Madagascar. A study of higher education reforms in Afghanistan illustrates how institutional instability, limited resources, and insufficient policy coordination hinder the implementation of student-centered and technology-enhanced learning (Katawazai, 2021). Analysis of technology use in Indonesian education similarly highlights gaps between national digital ambitions and local implementation capacities (Rabani et al., 2023). These cases suggest that barriers to digital learning are not unique to Madagascar but reflect broader structural conditions shared across many low-income education systems.

The growing body of literature on digital transformation emphasizes the need for holistic approaches that integrate technological, organizational, and human dimensions. Digital learning effectiveness depends on governance arrangements that support coordination, accountability, and sustainable investment (Salminen et al., 2020). In higher education institutions, fragmented leadership structures and limited financial autonomy often constrain innovation and long-term planning (Emynorane et al., 2025). Without coherent strategies that address infrastructure, professional development, and curriculum alignment, digital learning initiatives risk remaining peripheral to core educational processes.

The scientific approach adopted in this study is grounded in an integrative analysis of empirical studies and theoretical perspectives on digital learning, technology adoption, and educational development. By synthesizing findings from Madagascar and comparable contexts, the study situates digital learning barriers within broader debates on educational inequality, institutional capacity, and digital transformation. This approach allows for a contextualized understanding of digital learning challenges that move beyond technology-centric explanations and highlight the systemic conditions shaping implementation outcomes.

METHODOLOGY

This study uses a qualitative descriptive design to explore barriers to effective digital learning implementation in Madagascar, drawing on a careful analysis of empirical studies and context-specific evidence. An interpretive study orientation is used to examine how institutional arrangements, socio-economic conditions, and technological limitations shape digital learning practices within the education system. Instead of hypothesis testing, the study focuses on identifying, organizing, and explaining recurring patterns and constraints that influence the adoption and effectiveness of digital learning in the Malagasy context. This methodological choice enables an in-depth understanding of the underlying mechanisms that

hinder digital learning, including governance capacity, resource availability, and pedagogical readiness. By emphasizing contextual interpretation, the approach provides insights that are directly relevant to policy formulation and institutional improvement, offering a nuanced perspective that may not emerge from predominantly quantitative or indicator-driven analyses.

The data sources consist of peer-reviewed journal articles, policy-relevant academic studies, and prior empirical studies on education and digital learning in Madagascar and comparable developing contexts. Attention is given to studies addressing higher education effectiveness, infrastructure conditions, teacher capacity, and technology adoption. Data analysis is conducted using qualitative thematic analysis. Relevant texts are reviewed regularly, coded, and grouped into thematic categories, including infrastructure constraints, institutional capacity, pedagogical readiness, and socio-economic access. Through iterative comparison and synthesis, the analysis identifies the mechanisms by which these factors interact to hinder the implementation of digital learning. This analytical process enables a coherent explanation of the main issue by linking empirical observations with established theoretical perspectives on digital transformation and educational development.

RESULTS AND DISCUSSION

Infrastructural Deficits as a Foundational Barrier

The findings indicate that inadequate digital and physical infrastructure constitutes the most fundamental barrier to effective digital learning implementation in Madagascar. Limited access to stable electricity, unreliable internet connectivity, and insufficient availability of digital devices significantly constrain both institutional capacity and individual participation in digital learning. These infrastructure constraints affect not only rural and remote areas but also urban institutions, where bandwidth instability and resource scarcity remain persistent challenges. As a result, digital learning platforms are often underutilized or accessed intermittently, reducing their pedagogical effectiveness.

This result aligns with broader evidence demonstrating that learning outcomes are closely linked to the quality of educational spaces and material conditions. Study shows that infrastructure quality directly influences students' engagement, concentration, and ability to benefit from technology-mediated instruction (Andrade et al., 2024). In contexts where basic facilities are lacking, digital tools tend to amplify existing weaknesses rather than compensate for them. Similar patterns have been observed in schools where twenty-first-century technologies were introduced without addressing foundational access issues, leading to uneven and exclusionary outcomes (Male & Burden, 2013).

From a digital transformation perspective, these infrastructure limitations highlight the gap between technological aspirations and operational realities. Digital transformation requires stable technical systems as a prerequisite for organizational and pedagogical change (Vial, 2019). In Madagascar, infrastructure deficits function as a structural constraint that limits the scalability and sustainability of digital learning initiatives, suggesting that technological reforms must be preceded by substantial investment in basic educational infrastructure.

Institutional and Governance Capacity Constraints

Another key finding concerns the limited institutional and governance capacity to support the implementation of digital learning. Higher education institutions in Madagascar often lack coherent digital strategies, dedicated funding mechanisms, and coordinated leadership structures to manage technology integration effectively. Digital learning initiatives are frequently project-based, externally driven, and weakly embedded within institutional planning frameworks. This fragmentation undermines continuity and limits institutional learning from past initiatives.

These findings are consistent with prior analyses of higher education effectiveness in Madagascar, which emphasize governance fragility, weak coordination, and limited administrative capacity as systemic challenges (Emynorane et al., 2025). Without strong institutional frameworks, digital learning platforms remain peripheral rather than integrated into core teaching and learning processes. Comparable challenges

have been identified in other developing contexts, where policy ambitions for digital education outpace institutional readiness and implementation capacity (Rabani et al., 2023).

The literature on digital transformation underscores that governance structures play a central role in enabling or constraining technological change. Effective digital learning implementation requires alignment between policy objectives, institutional leadership, and operational practices (Vial, 2019). In the absence of such alignment, digital technologies risk becoming symbolic markers of modernization rather than tools for substantive educational improvement. The Malagasy case illustrates how governance limitations translate into practical barriers to the effectiveness of digital learning.

Limited Teacher Digital Competence and Professional Support

The results also reveal that insufficient teacher digital competence represents a major barrier to effective digital learning. Many educators lack formal training in digital pedagogy, instructional design for online environments, and the use of learning management systems. Therefore, digital platforms are often used for basic content delivery rather than interactive, student-centered learning. This limits the pedagogical potential of digital learning and reinforces traditional teaching practices in virtual formats.

This finding reflects broader patterns observed in developing education systems, where professional development opportunities for teachers are limited and unevenly distributed. A study on teacher professionalism highlights that inadequate institutional support and limited access to continuous training constrain teachers' ability to adapt to educational change (Emynorane et al., 2024). Studies focusing on teachers' perceptions of artificial intelligence and digital tools further indicate uncertainty, low confidence, and concerns about practical implementation in classroom settings (Mazı & Yıldırım, 2025).

The discussion of teacher competence is central to debates about the effectiveness of digital learning. Educational reforms that emphasize technology without investing in human capital tend to produce superficial change (Katawazai, 2021). Evidence from curriculum and language policy reforms shows that teachers' practices and beliefs significantly shape implementation outcomes (Jiang et al., 2019). In Madagascar, strengthening teacher digital competence emerges as a critical condition for translating technological access into meaningful learning experiences.

Socio-Economic Inequality and Unequal Access

Socio-economic inequality emerges as a pervasive barrier that shapes who benefits from digital learning initiatives. Students from low-income households face multiple constraints, including limited access to personal devices, high internet costs, and unsuitable home learning environments. These factors restrict participation in online learning and contribute to uneven learning experiences across socio-economic groups: digital learning, rather than reducing inequality, risks reinforcing existing educational disparities.

This result is consistent with research demonstrating that access to technology in education is deeply intertwined with social and economic conditions. Studies have shown that digital initiatives often privilege students who already possess material and cultural resources, leading to stratified outcomes (Male & Burden, 2013). Evidence from fragile and low-income contexts further indicates that household resilience and community resources play a decisive role in students' ability to engage with alternative learning modalities (Utsumi, 2022).

The findings also resonate with regional and international studies on the adoption of digital education. Study in Botswana reveals that students' engagement with AI-based tools depends heavily on access, institutional guidance, and digital literacy (Indrawati et al., 2025). In Madagascar, socio-economic inequality functions as a structural barrier that limits the inclusiveness of digital learning, underscoring the need for equity-oriented digital education policies.

Emerging Technologies and the Risk of Premature Adoption

The analysis indicates that while artificial intelligence and advanced digital tools offer potential opportunities, their adoption in Madagascar remains constrained by unresolved foundational challenges. AI-driven learning systems promise personalized learning, efficiency gains, and improved academic outcomes (Adewale et al., 2024; Tian & Zhang, 2025). However, in practice, limited infrastructure, low digital literacy, and weak governance frameworks restrict their effective use within Malagasy institutions.

Studies on AI in higher education suggest that sustainable implementation requires robust institutional readiness, ethical governance, and user competence (Bagherimajd & Khajedad, 2025; Boaro et al., 2025). Open-source AI assistants and learning management system integrations demonstrate pedagogical potential in contexts where technical and human capacities are well established (Alier et al., 2025). In Madagascar, the absence of these enabling conditions raises concerns that AI adoption may widen digital divides rather than enhance learning quality (Aderibigbe et al., 2025).

This discussion highlights the importance of sequencing in digital education reform. Introducing advanced technologies without addressing basic infrastructural, institutional, and pedagogical barriers risks creating new forms of exclusion. The findings support the argument that the effectiveness of digital learning depends on strengthening foundational systems before pursuing technologically sophisticated solutions, reinforcing a context-sensitive approach to educational digitalization.

CONCLUSION

This study concludes that barriers to effective digital learning implementation in Madagascar are shaped by interconnected challenges, including infrastructure constraints, weak institutional governance, insufficient teacher digital competence, and persistent socio-economic inequality. Although digital technologies and emerging artificial intelligence applications present opportunities to improve access and learning quality, their impact remains limited by unresolved foundational conditions within the education system. Practical solutions, therefore, require an integrated approach that prioritizes investment in basic digital and physical infrastructure, strengthens institutional coordination and policy coherence, and expands continuous professional development for educators with an emphasis on digital pedagogy. Targeted measures to promote equitable access for disadvantaged learners are essential to avoid reinforcing existing educational disparities. Future research is encouraged to incorporate empirical fieldwork at the institutional and classroom levels to examine implementation processes and learning outcomes, and to conduct comparative analyses across similar low-income contexts to support the development of more context-sensitive digital education policies.

REFERENCES

- Aderibigbe, S. A., Omar, M., ElMehdi, H., Colucci-Gray, L., Hamad, K., Shanableh, A., AlOthman, H., & Alotaibi, E. (2025). Artificial intelligence-driven prediction of optimal technology-aided alternative operations in post-emergency contexts: A case study from an Emirati university. *International Journal of Educational Research Open*, 9. <https://doi.org/10.1016/j.ijedro.2025.100473>
- Adewale, M. D., Azeta, A., Abayomi-Alli, A., & Sambo-Magaji, A. (2024). Impact of artificial intelligence adoption on students' academic performance in open and distance learning: A systematic literature review. *Heliyon*, 10(22). <https://doi.org/10.1016/j.heliyon.2024.e40025>
- Alier, M., Pereira, J., García-Peñalvo, F. J., Casañ, M. J., & Cabré, J. (2025). LAMB: An open-source software framework to create artificial intelligence assistants deployed and integrated into learning management systems. *Computer Standards and Interfaces*, 92. <https://doi.org/10.1016/j.csi.2024.103940>
- Andrade, A. E., Padilla, L., & Carrington, S. J. (2024). Educational spaces: The relation between school infrastructure and learning outcomes. *Heliyon*, 10(19). <https://doi.org/10.1016/j.heliyon.2024.e38361>

- Anwar, A. S., Mardisentosa, B., & Williams, A. (2021). The Role of Technology in Education. *IAIC Transactions on Sustainable Digital Innovation (ITSDI)*, 3(1), 36–40. <https://doi.org/10.34306/itsdi.v3i1.524>
- Bagherimajd, k., & khajedad, K. (2025). Designing a model of sustainable education based on artificial intelligence in higher education. *Computers and Education: Artificial Intelligence*, 9. <https://doi.org/10.1016/j.caeai.2025.100439>
- Boaro, A., Mezzalira, E., Siddi, F., Bagattini, C., Gabrovsky, N., Marchesini, N., Broekman, M., Sala, F., Ivanov, M., Ringel, F., Tessitore, E., Sampron, N., Boaro, A., & Staartjes, V. E. (2025). Knowledge, interest, and perspectives on Artificial Intelligence in Neurosurgery. A global survey. *Brain and Spine*, 5. <https://doi.org/10.1016/j.bas.2024.104156>
- Boretti, A. (2025). A narrative review of solar electric propulsion for space missions: Technological progress, market opportunities, geopolitical considerations, and safety challenges. *Journal of Space Safety Engineering*, 12(3). <https://doi.org/10.1016/j.jsse.2025.07.004>
- Emynorane, R. H., Huda, M., Degeng, I. N. S., Supriyanto, A., & Citriadin, Y. (2024). Challenges and Supports for Enhancing Teacher Professionalism in Private High Schools of Malang: A Qualitative Study. *AL-ISHLAH: Jurnal Pendidikan*, 16(2), 1606–1615. <https://doi.org/10.35445/alishlah.v16i2.5215>
- Emynorane, R. H., Ibrahim, M. A., Hasniati, & Yunus, M. (2025). Challenges to the Effectiveness of Higher Education in Madagascar: An Analysis of Key Hindering Factors. *KnE Social Sciences*, 10(18), 579–595. <https://doi.org/10.18502/kss.v10i18.19486>
- Espinosa A. A., Padilla, L., & Carrington, S. J. (2024). Educational spaces: The relation between school infrastructure and learning outcomes. *Heliyon*, 10(19). <https://doi.org/10.1016/j.heliyon.2024.e38361>
- Indrawati, L., K. P., Kurniawan, K., & Muthaiyah, S. (2025). Adoption of ChatGPT in educational institutions in Botswana: A customer perspective. *Asia Pacific Management Review*, 30(1). <https://doi.org/10.1016/j.apmr.2024.100346>
- Jiang, L., Zhang, L. J., & May, S. (2019). Implementing English-medium instruction (EMI) in China: Teachers' practices and perceptions, and students' learning motivation and needs. *International Journal of Bilingual Education and Bilingualism*, 22(2), 107–119. <https://doi.org/10.1080/13670050.2016.1231166>
- Katawazai, R. (2021). Implementing outcome-based education and student-centered learning in Afghan public universities: the current practices and challenges. *Heliyon*, 7(5). <https://doi.org/10.1016/j.heliyon.2021.e07076>
- Male, T., & Burden, K. (2013). Access denied? Twenty-first-century technology in schools. *Technology, Pedagogy and Education*, 23(4), 423–437. doi:10.1080/1475939x.2013.864697
- Mazi, A., & Yıldırım, İ. O. (2025). Primary school teachers' opinions on the use of artificial intelligence in educational practices. *Social Sciences and Humanities Open*, 11. <https://doi.org/10.1016/j.ssaho.2025.101576>
- Rabani, S., Khairat, A., Guilin, X., & Jiao, D. (2023). The Role of Technology in Indonesian Education at Present. *Journal of Computer Science Advancements*, 1(2). 85-91 <https://doi.org/10.70177/jsca.v1i2.403>
- Salminen, J., Hopf, M., Chowdhury, S. A., Jung, S., Almerexhi, H., & Jansen, B. J. (2020). Developing an online hate classifier for multiple social media platforms. *Human Centric Computing and Information Sciences*, 10(1), 1. <https://doi.org/10.1186/s13673-019-0205-6>
- Tian, J., & Zhang, Y. (2025). Does artificial intelligence help improve human capital-based educational development? Evidence from 29 countries. *Technology in Society*, 83. <https://doi.org/10.1016/j.techsoc.2025.103004>

- Utsumi, Y. (2022). Armed conflict, education access, and community resilience: Evidence from the Afghanistan NRVA Survey 2005 and 2007. *International Journal of Educational Development*, 88. <https://doi.org/10.1016/j.ijedudev.2021.102512>
- Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information*, 28(2), 118–144. <https://doi.or>