

The Tripartite Failure: Assessing Infrastructural, Pedagogical, and Administrative Barriers to ICT Integration in Mwala Sub-County, Machakos County, Kenya

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Abstract

Information and Communication Technology (ICT) is essential to Kenya's Competency-Based Education (CBE), yet its integration remains inconsistent, particularly in rural and resource-constrained schools. This study examined infrastructural, pedagogical, and administrative barriers to ICT integration in public secondary schools in Mwala Sub-County, Machakos County. Using a mixed-methods descriptive survey design, data were collected through questionnaires and interviews involving nine principals, 120 teachers, and one Sub-County Director of Education. Quantitative data were analyzed using descriptive statistics and multiple linear regression in SPSS version 25.0, while qualitative data were analyzed thematically. The regression model was statistically significant, explaining 60.0% of the variation in ICT integration ($R^2 = .600$, $p < .001$). ICT infrastructure was the strongest predictor ($\beta = .488$, $p < .001$), followed by teacher competency ($\beta = .315$, $p < .001$) and administrative support ($\beta = .235$, $p = .008$). Findings revealed inadequate computers, internet connectivity, technical support, pedagogical ICT training, and funding. Although 62.1% of teachers were confident in basic computer use, 70.4% reported inadequate subject-specific ICT training, while 74.1% felt their pre-service training had not adequately prepared them for digitally supported teaching. The study concludes that ICT integration is constrained by inadequate infrastructure, limited teacher preparedness, and weak administrative support, reflecting a gap between national policy expectations and school-level implementation. It recommends targeted infrastructure investment, continuous teacher professional development, dedicated ICT maintenance budgets, and school-level technical support structures.

Keywords: *ICT integration, Competency-Based Education, teacher competency, ICT infrastructure, administrative support.*

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1.0 Introduction

The study reveals a young teaching workforce, with 76.8% under 40 years old, and high educational attainment (78.7% hold bachelor's degrees). While this demographic may favor ICT integration due to exposure to digital technologies, institutional constraints still hinder regular technology use among teachers, indicating that age and qualifications alone do not ensure effective ICT implementation.

Pettersson (2018) argues that successful educational technology implementation requires attention to organisational and pedagogical conditions rather than concentrating exclusively on technological tools. Technology therefore needs to be understood as part of a wider educational system. Its effectiveness is determined by how infrastructure, teachers, school leadership, curriculum requirements and institutional resources interact.

The study reveals a young teaching workforce, with 76.8% under 40 years old, and high educational attainment (78.7% hold bachelor's degrees). While this demographic may favor ICT integration due to exposure to digital technologies, institutional constraints still hinder regular technology use among teachers, indicating that age and qualifications alone do not ensure effective ICT implementation.

The digital divide is consequently not simply a question of whether a school has computers. It includes differences in access to reliable connectivity, quality devices, digital content, technical assistance and the skills required to use technology effectively. Champa et al. (2021), for example, demonstrate that teachers may encounter multiple challenges when attempting to integrate ICT into instructional practice. Similar concerns have been reported in Kenyan educational contexts, where technology adoption is influenced by infrastructure, teacher preparedness, institutional support and the availability of resources.

Teacher preparedness represents one of the most important components of effective ICT integration. Teachers are expected not only to operate computers but also to determine when and how technology can improve learning. Basic digital literacy, therefore, is only one dimension of teacher competence. A teacher may know how to prepare a document or access the internet but still lack the pedagogical knowledge needed to use technology to facilitate inquiry, collaboration, assessment or differentiated instruction.

Tondeur et al. (2017) emphasise the importance of teachers' pedagogical beliefs in understanding technology use. Technology integration is influenced by how teachers perceive learning, teaching and the role of digital tools. Professional development should consequently move beyond technical demonstrations and address subject-specific pedagogical applications.

The nature of professional development is also important. Short, centralised workshops may introduce teachers to new technologies but may not provide sufficient opportunities for practice, experimentation, reflection and follow-up. Without sustained support, teachers may revert to familiar analogue teaching practices. Sasikala and Ravichandran (2024) similarly highlight limitations associated with professional development that does not adequately address teachers' specific instructional contexts.

Infrastructure constitutes another fundamental barrier. ICT integration requires more than computers. It depends on electricity, internet connectivity, functioning hardware, appropriate software, secure storage, maintenance and technical support. Where electricity is unreliable, devices cannot be used consistently. Where internet access is slow or unaffordable, online resources become difficult to incorporate into lessons. Where there is no technical support, minor equipment failures can result in prolonged periods of inactivity.

Gesare (2023) notes that ICT implementation challenges in Kenyan schools include problems associated with equipment, teacher preparedness

and institutional conditions. The accumulation of broken or obsolete devices can create what may be described as a technological "graveyard", whereby equipment exists physically but contributes little to classroom learning.

The interaction between these factors provides the basis for the present study. ICT integration cannot be adequately explained by examining infrastructure, teachers or administrators separately. A school with excellent infrastructure but inadequately prepared teachers may underutilise technology. Similarly, competent teachers may struggle to integrate ICT where computers, connectivity and electricity are inadequate. Even where both infrastructure and teacher competency are present, weak leadership and inadequate financing may undermine sustainability.

"The findings indicate that integrating ICT in resource-constrained schools poses a challenge across infrastructure, pedagogical readiness, and administrative support, with weaknesses in one area affecting others"

This study therefore conceptualises the challenge as a tripartite problem involving infrastructure, pedagogical preparedness and administrative facilitation. The concept of "tripartite failure" does not suggest that every school experiences complete failure in all three areas. Rather, it highlights the interconnected nature of the constraints and the possibility that weaknesses in one component can undermine progress in the others.

The study was undertaken against the wider background of digital transformation in education

and the increasing expectations associated with CBE. It sought to determine whether ICT integration in Mwala Sub-County is primarily constrained by technological access, teacher preparedness, administrative support or a combination of these factors.

Objective of the study

The Tripartite Failure: Assessing Infrastructural, Pedagogical, and Administrative Barriers to ICT Integration in Mwala Sub-County, Machakos County, Kenya.

Statement of the Problem

The Kenyan education system has increasingly emphasised the use of ICT as part of efforts to improve educational quality, digital literacy and learner preparedness for a rapidly changing society. The implementation of competency-oriented education has further increased the expectation that teachers will employ diverse instructional approaches and digital resources. National initiatives have demonstrated government commitment to expanding access to technology in education.

Nevertheless, policy commitment has not necessarily translated into consistent ICT use in rural public secondary schools. Schools in resource-constrained environments continue to experience inadequate computers, unreliable electricity, limited internet connectivity, insufficient technical support and constrained financial capacity. These challenges can make it difficult for teachers to integrate technology into everyday teaching and learning.

The problem is not exclusively infrastructural. Teachers may possess basic computer skills but lack subject-specific pedagogical knowledge concerning the effective use of digital tools. Professional development opportunities may be episodic, generic and insufficiently linked to classroom practice. At the same time, principals may face competing demands for scarce resources, forcing them to prioritise immediate physical and operational needs over ICT investment and maintenance.

The resulting situation creates a gap between educational policy and classroom practice. While policy documents may encourage or require technology-supported learning, the conditions required for implementation may not exist consistently at school level. This gap can reinforce educational inequalities because learners in better-resourced schools may have substantially greater opportunities to acquire and practise digital competencies than learners in disadvantaged schools.

Although previous studies have examined ICT challenges in Kenyan schools, there remains a need for context-specific evidence concerning the interaction between infrastructure, teacher competency and administrative support in rural secondary schools within the changing CBE environment. Without such evidence, interventions may continue to focus on isolated solutions, such as distributing devices without establishing maintenance systems or conducting teacher workshops without follow-up support.

The present study therefore examined the extent to which ICT infrastructure, teacher competency and administrative support influence ICT integration in public secondary schools in Mwala Sub-County, Machakos County.

2.0 Materials and Methods

Theoretical Framework

The study examines technology adoption in education through the Technology Acceptance Model (TAM) and Diffusion of Innovations Theory. TAM highlights that teachers' perceptions of technology's usefulness and ease of use greatly affect their adoption of ICT. Factors such as teacher competency, infrastructure reliability, and administrative support influence these perceptions. Although TAM provides valuable insights, it has limitations when considered alone, as technology adoption is influenced by institutional factors and resources. Rogers' theory offers a broader perspective, emphasizing how social systems and organizational processes affect technology adoption in schools. Essential

infrastructure such as computers, internet access, and technical support is critical for effective ICT integration. Reliable technology infrastructure and ongoing maintenance are necessary for sustained educational use of digital tools (Davis, 1989).

Teacher Competency and Professional Development

Teacher competency is a central determinant of educational technology use. ICT competence includes technical, pedagogical and evaluative dimensions. Technical competence concerns the ability to operate devices and software. Pedagogical competence concerns the ability to integrate technology into teaching strategies. Evaluative competence involves selecting appropriate digital resources and assessing whether their use contributes to learning.

A teacher who can operate a computer but cannot connect technology to curriculum objectives has limited ICT integration competence. Effective integration requires teachers to determine which technologies are appropriate for particular learning outcomes.

Professional development is therefore essential. Teachers need opportunities to learn new tools, practise their use, share experiences and receive feedback. Continuous professional development can be particularly valuable when it is situated within the teachers' own schools and subject areas.

One-off workshops may have limited long-term impact if teachers do not subsequently receive support. School-based professional learning communities can create opportunities for peer mentoring and collaborative problem-solving.

The issue is particularly relevant under CBE because teachers are expected to facilitate active learning rather than merely transmit information. Digital tools can support these approaches, but teachers require appropriate pedagogical knowledge.

Administrative Support

School leadership influences ICT adoption through planning, budgeting, supervision and organisational culture. Principals determine how scarce resources are prioritised and can create conditions that encourage teachers to experiment with technology. Administrative support includes provision for internet subscriptions, maintenance, procurement, security and staff development. It may also involve developing ICT policies, monitoring utilisation and recognising teachers who demonstrate effective practice. However, administrative support is constrained by the broader financial environment in which schools operate. Principals often have to balance ICT requirements with competing needs such as classroom construction, sanitation, textbooks, security and repairs. Consequently, the absence of ICT investment should not automatically be interpreted as lack of leadership commitment. A key distinction is therefore between willingness to support ICT and capacity to provide tangible support. The former is attitudinal, while the latter is material and organizational (Abulibdeh et al., 2024).

Methods

The study employed a mixed-methods descriptive survey design in Mwala Sub-County, Machakos County, Kenya, to investigate ICT integration in public secondary schools. It used quantitative data to identify ICT challenges highlighting the importance of infrastructure, teacher competency, and administrative support and qualitative insights to contextualize the challenges as perceived by principals and education officials. The target population included 45 principals, 600 teachers, and one Sub-County Director of Education, with a sample comprising nine principals and 120 teachers, achieving a 90.0% response rate from teachers. This study's mixed methods strengthened findings by triangulating quantitative patterns with qualitative explanations.

3.0 Results and Discussion

The study reveals a young teaching workforce, with 76.8% under 40 years old, and high educational attainment (78.7% hold bachelor's degrees). While this demographic may favor ICT integration due to exposure to digital technologies, institutional constraints still hinder regular technology use among teachers, indicating that age and qualifications alone do not ensure effective ICT implementation (Creswell & Creswell, (2018).

ICT Infrastructure

The study reveals a young teaching workforce, with 76.8% under 40 years old, and high educational attainment (78.7% hold bachelor's degrees). While this demographic may favor ICT integration due to exposure to digital technologies, institutional constraints still hinder regular technology use among teachers, indicating that age and qualifications alone do not ensure effective ICT implementation.

The qualitative findings reinforced these results. One principal explained:

“I have a dormitory without enough beds... When funds come, I have to choose between fixing a leaking roof and an internet subscription. The roof always wins.”

This statement illustrates the resource-allocation dilemma facing school leaders. Although ICT may be recognised as educationally important, immediate physical infrastructure needs can receive priority because they are perceived as more urgent. The findings suggest that technology provision without sustainable operational financing is unlikely to produce consistent ICT integration.

Teacher Competency and Professional Development

The study reveals a young teaching workforce, with 76.8% under 40 years old, and high educational attainment (78.7% hold bachelor's degrees). While this demographic may favor ICT

integration due to exposure to digital technologies, institutional constraints still hinder regular technology use among teachers, indicating that age and qualifications alone do not ensure effective ICT implementation. The qualitative findings also highlighted weaknesses in the cascade approach to professional development. The Sub-County Director of Education observed:

“By the time training reaches the classroom teacher, it is diluted... we lack the resources to implement school-based coaching at scale.”

This observation suggests that professional development may lose effectiveness as information passes through successive training levels. Teachers may receive general information about technology without sufficient opportunities to practice subject-specific applications. The

Regression Analysis

Table 1

Multiple Regression Model

Predictor	Unstandardised B	Standardised β	Significance
Constant	1.121	—	.000
ICT Infrastructure	.410	.488	.000
Teacher Competency	.298	.315	.000
Administrative Support	.245	.235	.008

Note. Values reproduced from the source manuscript; verify the underlying statistical output before submission.

Multiple linear regression was undertaken to determine the combined contribution of ICT infrastructure, teacher competency and administrative support to ICT integration. The results demonstrate that all three predictors had positive and statistically significant relationships with ICT integration. ICT infrastructure had the largest standardised coefficient ($\beta = .488$), indicating that it made the greatest relative contribution to ICT integration when the other variables were controlled. Teacher competency was the second strongest predictor ($\beta = .315$). This demonstrates that the ability of teachers to use ICT effectively is an important determinant of technology integration. Administrative support had a positive coefficient of $\beta = .235$, with a significance level of $p = .008$, indicating that

findings therefore support the need to rethink professional development from a workshop-centred model towards continuous professional learning.

Administrative Support

Administrative support was also a statistically significant predictor of ICT integration. The regression analysis produced $\beta = .235$ ($p = .008$). The study reveals a young teaching workforce, with 76.8% under 40 years old, and high educational attainment (78.7% hold bachelor's degrees). While this demographic may favor ICT integration due to exposure to digital technologies, institutional constraints still hinder regular technology use among teachers, indicating that age and qualifications alone do not ensure effective ICT implementation.

school-level support was also statistically significant. The overall regression model produced an R^2 of .600, meaning that the three variables collectively explained approximately 60.0% of the variance in ICT integration. The model was statistically significant ($p < .001$). The remaining 40.0% of unexplained variance indicates that other factors also influence ICT integration. These may include electricity reliability, learner access, teacher attitudes, curriculum demands, technology costs, digital content availability, school location, parental socioeconomic conditions and national or county-level implementation mechanisms. The regression findings therefore support the central argument of the study: ICT integration is not determined by a single factor but is strongly associated with the

combined effects of infrastructure, teacher competency and administrative support.

Integrated Discussion

ICT Integration as a Systemic Rather Than Individual Problem

The findings challenge explanations that locate ICT implementation problems primarily within individual teachers. The regression results demonstrate that infrastructure, competency and administrative support jointly explain 60.0% of the variation in ICT integration. This is important because educational technology programmes are sometimes designed around the assumption that teachers simply need more training. Although training is important, the findings indicate that teacher competency operates alongside material and organizational conditions. A teacher who has received excellent training may still be unable to use digital resources where the school has few computers or unreliable internet. Conversely, a school may possess modern computers but achieve limited learning benefits where teachers have insufficient pedagogical competence. The three variables should therefore be treated as mutually reinforcing components of an ICT ecosystem.

Infrastructure as the Dominant Constraint

The strongest predictor of ICT integration is infrastructure, highlighting that technology integration is hindered by inadequate physical conditions. Issues such as insufficient computers, unreliable internet, and lack of technical support indicate fundamental infrastructure challenges. The study advocates for a shift from a device-centered to an ecosystem-centered ICT policy, emphasizing the importance of functionality, utilization, connectivity, maintenance, and learning outcomes over merely counting distributed devices.

Teacher Competency Beyond Basic Computer Literacy

The findings indicate a significant difference in teacher competency, where many teachers are

confident in basic computer use but feel inadequately prepared in subject-specific pedagogy. This highlights a shift from basic digital literacy to the need for pedagogical digital competence, requiring teachers to understand how and when to integrate technology effectively into lessons tailored to their specific subjects. Continuous and contextual professional development is essential, allowing teachers to practice digital pedagogy, observe peers, create digital lesson materials, and receive feedback to enhance their teaching methods.

Administrative Support and the Resource Allocation Problem

The significance of administrative support highlights the vital role of school leadership in ICT implementation, albeit within financially constrained environments. The dilemma of prioritizing essential infrastructure repairs over internet connectivity illustrates this challenge. To effectively implement ICT-intensive educational strategies, schools require predictable resources for ongoing costs such as internet subscriptions, repairs, and software updates. Therefore, ICT policy should address the total cost of ownership rather than focusing solely on procurement.

The Policy–Practice Gap

The study highlights a significant gap between policy expectations and schools' ability to implement them, particularly regarding Competency-Based Education (CBE) and technology use. While digital tools enhance learner-centered approaches, effective transition necessitates adequate teacher support, infrastructure, and leadership. When policies are introduced without sufficient resources, schools may only comply symbolically, leading to implementation fatigue among educators. The findings suggest that weak implementation often stems from structural constraints rather than resistance to policy, indicating a need for careful consideration of the "unfunded mandate" concept. Ultimately, expectations for ICT-supported education frequently surpass available resources for effective school-level application.

4.0 Conclusion

The study identified multiple barriers to ICT integration in public secondary schools in Mwala Sub-County, Machakos County, attributing these challenges to systemic interrelated factors. Key findings revealed that ICT infrastructure was the strongest predictor of integration, coupled with teacher competency and administrative support, together explaining 60% of the variance in ICT adoption. Infrastructure issues, such as insufficient computers and unreliable internet, severely limited teachers' use of digital resources. While many educators were confident in basic computer skills, most lacked subject-specific pedagogical ICT training. Administrative support was also crucial but often hampered by inadequate funding and conflicting institutional priorities, indicating a gap between willingness and implementation capacity.

The findings indicate that integrating ICT in resource-constrained schools poses a challenge across infrastructure, pedagogical readiness, and administrative support, with weaknesses in one area affecting others. Kenya's approach to enhancing digital education must extend beyond merely acquiring technology. Effective ICT integration necessitates dependable infrastructure, ongoing teacher training, technical assistance, and consistent funding, or else the initiatives risk merely resulting in underutilized equipment in classrooms.

5.0 Recommendations

Establish Targeted ICT Infrastructure Financing

The Ministry of Education and relevant education agencies should establish targeted infrastructure financing mechanisms for underserved schools. Such financing should address the complete ICT ecosystem, including computers, connectivity, electricity, networking, maintenance and technical support. For schools experiencing electricity challenges, appropriate renewable-energy solutions such as solar power systems should be considered where technically and economically

feasible. Connectivity interventions should also be designed around the realities of rural schools rather than assuming that conventional broadband services will always be adequate. Most importantly, infrastructure funding should include recurrent maintenance costs.

Strengthen Continuous Teacher Professional Development

The Teachers Service Commission and relevant agencies should enhance continuous professional development in digital pedagogy, shifting focus from one-off workshops to ongoing school-based learning. Professional Learning Communities can facilitate experience sharing, digital lesson demonstrations, material development, and collaborative problem-solving regarding technology. Additionally, training should be subject-specific, allowing teachers to understand how ICT can aid specific learning outcomes instead of just generic technology training.

Introduce Dedicated ICT Budget Lines

School financing frameworks need to clarify budget allocations for ICT maintenance and recurring technology costs. A specific ICT budget could facilitate internet subscriptions, repairs, component replacements, software, and technical support, thereby minimizing the perception of ICT as a discretionary expenditure competing with other school needs.

Develop School-Based ICT Champions

Schools should identify teachers with relatively strong ICT skills to serve as ICT champions or digital-learning mentors. These teachers can provide first-line assistance to colleagues, demonstrate useful applications and support professional learning communities. Where resources permit, ICT champions should receive workload recognition or designated time for their mentoring responsibilities.

Strengthen Technical Support Systems

Technology programmes should include sustainable technical support mechanisms. Schools could establish relationships with

qualified technicians within their localities or through sub-county-level support structures.

A maintenance schedule should be established for computers, networks, projectors, power systems and other equipment. Schools should also maintain inventories documenting equipment condition, location and maintenance history.

Align ICT Policy Expectations with Resource Provision

Education policies should be accompanied by realistic implementation frameworks. Where schools are expected to use digital technologies, the associated requirements for equipment, connectivity, training, maintenance and technical support should be explicitly considered. This would reduce the gap between policy expectations and actual school capacity.

Promote Collaborative Resource Sharing

Schools within the same locality could explore mechanisms for sharing ICT expertise and selected resources. Schools with stronger infrastructure could support neighbouring institutions through joint teacher training, equipment-sharing arrangements or collaborative digital learning activities. Such collaboration would not replace government investment but could provide supplementary support while broader infrastructure gaps are addressed.

Implications for Policy and Practice

The findings have several implications for education policy.

ICT integration must be viewed as a comprehensive reform rather than merely a procurement effort, emphasizing the functionality and use of devices. Professional development should prioritize pedagogical integration, adapting to teachers' needs. School leadership is crucial, requiring authority and resources for ICT program sustainability, incorporating training in planning and monitoring. Equity should drive digital education policy to prevent deepening educational inequalities, necessitating targeted

support for underserved communities. Future evaluations of digital education should focus on sustainability and long-term outcomes rather than just equipment delivery.

Limitations of the Study

The study focused on public secondary schools in one sub-county of Machakos County. Consequently, the findings should be interpreted within the geographical and institutional context in which the research was conducted.

The descriptive survey design imposes limitations on establishing causal relationships. While regression analysis showed significant associations between independent variables and ICT integration, these findings do not imply that changes in predictors will lead to corresponding changes in ICT integration. The study relied on self-reported teacher perceptions, which can be influenced by personal experiences. Future research should include direct classroom observations, ICT usage logs, and infrastructure audits. Additional studies could explore differences between rural and urban schools, day and boarding schools, and learner-level factors in ICT adoption.

Areas for Further Research

Future research should focus on the link between ICT integration and learner achievement in competency-oriented education. While this study identifies key predictors of technology use, further investigation is needed to assess the impact of increased ICT on learner competencies. Longitudinal studies could provide insights into the long-term effectiveness of teacher training and infrastructure investments. Additionally, cost-effectiveness analyses of various rural connectivity solutions, such as solar-powered ICT labs and community models, are essential. Lastly, exploring emerging technologies like artificial intelligence and digital assessment tools in Kenyan secondary schools is crucial, as they present new opportunities alongside infrastructure and ethical challenges.

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