Journal of Education, 2025
Issue 101, http://journals.ukzn.ac.za/index.php/joe http://dx.doi.org/10.17159/2520-9868/i101a02

CC BY NC ND

Infrastructural challenges impeding the integration of Information Communication Technology in South African Schools: The case of Bushbuckridge, Mpumalanga Province, South Africa

Phiwayinkosi R. Gumede

Quality Management Directorate, Mangosuthu University of Technology, Durban, South Africa
siphiweg@mut.ac.za
https://orcid.org/0000-0002-9203-8457

Andiso Ngobe

College of Education, Curriculum and Instructional Studies, University of South Africa, Pretoria, South Africa
ngobeandiso1@gmail.com
https://orcid.org/0009-0006-4195-1699

(Received: 13 December 2024; accepted: 12 August 2025)

Abstract

In this study, we examine infrastructural challenges that impede effective integration of information and communication technology (ICT) in selected Bushbuckridge secondary schools in Mpumalanga Province, South Africa. We employed a qualitative approach and collected data through interviews and observations involving 20 teachers. We used the thematic analysis technique to analyse the data. We identified key barriers to ICT adoption, including inadequate hardware and software, poor maintenance, limited funding, frequent theft and vandalism of ICT resources, and an unreliable electricity supply. We recommend approaches for improving infrastructure, reinforcing maintenance systems, and enhancing security measures. It is crucial to address these issues if we are to promote equitable access to digital learning and ensure that technology makes a meaningful contribution to educational imperatives, particularly in rural schools.

Keywords: digital divide, educational infrastructure, information technology communication, ICT integration, rural school, Technological Acceptance model

Introduction

ICT has become an integral part of modern life; it exerts significant influence in various sectors, such as education (Saba et al., 2023). The digitalisation of ICT has become an engine for economic growth and development (Saba et al., 2025). Consequently, digital technologies have immense potential for reshaping the global educational landscape. In the context of this

study, ICTs encompass laptops, the internet, Management Information Systems (MIS), smartboards, tablets, and projectors and are, therefore, technologies relevant to teaching, learning, and assessment. The evolution of digital technologies suggests that many countries view ICT as a valuable tool for enhancing the quality of education and accelerating progress toward the attainment of the Sustainable Development Goals, particularly Goals 4 and 10 (Costa et al., 2024). These Goals focus on ensuring inclusive, equitable, quality education for all and on reducing inequalities in nations by 2030. As technologies grow to impact every aspect of our lives, it is becoming increasingly necessary for us all to recognise their significance and benefits. Therefore, being knowledgeable about ICT use can lead one to increased connectivity with others, as well as ensuring greater educational experiences and job opportunities (Alenezi et al., 2023; Gonfa et al., 2024)

In recent times, the world has grappled with challenges resulting from the COVID-19 pandemic, and educational institutions have not been spared. During this period, they used digital technologies to ensure business continuity and minimise disruptions in learning and teaching. This forced swift transition emphasised globally the growing need for a strong ICT infrastructure in schools. Although some institutions did make ICT infrastructure available, many schools and teachers faced significant challenges in incorporating ICT effectively into teaching and learning (Ramorola, 2013). Different studies conducted in Ghana and South Africa have revealed that the lack of resources, insufficient training, and inadequate infrastructure are among the hindrances towards the effective integration of ICT in education (Chisango & Marongwe, 2021; Lomo et al., 2025; Mangundu et al., 2025). A similar study conducted in Rwanda reported limited internet access, a shortage of skilled human resources, inadequate project management, inadequate infrastructure, and insufficient maintenance of ICT equipment as barriers to the successful integration of ICT (Mushimiyimana et al., 2025). Additionally, Chisango and Marongwe (2021) and Mangundu et al. (2025) have claimed that the persistent problem is caused by the theft of ICT infrastructure in schools.

In this study, we examine the infrastructural challenges that hinder the utilisation of ICT in schools in the Bushbuckridge area of the Mpumalanga Province in South Africa. We employed a qualitative approach to delve into the complex issues surrounding ICT infrastructure in the Bohlabela Education District. Through a deeper understanding of infrastructural challenges, we seek to contribute to the broader discourse on improving ICT access and implementation in South African schools, particularly in rural and under-resourced areas.

Problem statement

The integration of ICT in education remains a challenge across most countries in sub-Saharan Africa (Mushimiyimana et al., 2025). Rural areas, such as Bushbuckridge face distinct challenges that exacerbate the difficulties in integrating ICT in schools. The Integrated Development Plan of the Bushbuckridge Local Municipality for the 2023–2024 financial year reported a high unemployment rate of 53.2% as of 2020, along with 219,803 Child Grant recipients and 42,129 Old Age Grant recipients (Bushbuckridge Local Municipality, 2023).

These figures point to the socio-economic status of the Bushbuckridge population and suggest that most learners in this area come from disadvantaged family backgrounds with some parents being unemployed. Consequently, the integration of ICT suffers because parents are unable to procure the items, like laptops and tablets, for example, that support the implementation of ICT.

Although many studies have been conducted in rural areas, those that have focused explicitly on the infrastructural challenges hindering the effective implementation of ICT in such settings are limited. Without a deeper understanding of these infrastructural deficits, the potential of ICT to improve learner success will remain unrealised in these communities. Therefore, we aimed to address the question: What are the key infrastructural challenges that hinder the integration of ICT in schools, and what strategies should be implemented to mitigate these barriers?

Purpose of the study

The purpose of this study was to explore the infrastructural challenges that hinder the integration of ICT in rural schools and to propose strategies to enhance ICT integration. The ultimate goal is to contribute to the broader discourse on improving digital access in rural schools and to recommend interventions that can bridge the gap between rural and urban education through the effective use of ICT.

Literature review

Globally, there is clear evidence that ICT has a significant impact on societies, particularly in the field of education. Chisango and Marongwe (2021) have asserted that ICT plays a crucial role in the political, social, and economic sectors in this information age. Its role in education is becoming more visible as we observe the complementary strengths between technology-enhanced learning and traditional approaches to teaching (Mhlongo et al., 2023). Such complementary strengths have been welcomed widely, given the many benefits and opportunities that ICT offers in education. As Salam et al. (2018) have noted, ICT serves as a powerful catalyst for innovation in education so its potential in relation to learning and teaching must be viewed in a positive light. Although the use of ICTs is applauded, Ajani (2024) cautioned that the success of digital transformation hinges on the proactive involvement and participation of all stakeholders so they must be involved in achieving a seamless ICT integration.

Challenges affecting ICT integration in schools

The increasing access to digital tools has led to the increasing integration of ICT in education and this has presented numerous opportunities and challenges (Alenezi et al., 2023). In South Africa, the government's constant struggle to provide quality education in rural areas is being highlighted as having an adverse impact on teaching and learning outcomes (Ajani, 2024). Despite some progress that has been made in the integration of ICT, rural schools still struggle with the inadequate infrastructure and resources that continue to sustain the digital

divide that hampers students' educational experiences and outcomes (Mkhonto & Mubangizi, 2024). Notably, most schools in rural settings face numerous challenges, including teachers' lack of ICT competency, inadequate ICT infrastructure, insufficient ICT policies, poor network connections, unreliable electricity supply, and limited professional development for teachers (Kaur, 2023; Othman et al., 2024). To realise the benefits and opportunities of ICT, the identified challenges must be addressed, or the digital divide will continue to increase, and more learners will be disadvantaged and left behind.

Infrastructural challenges

In many developing and rural areas, infrastructural challenges persist as significant barriers to the integration of ICT in education. A major obstacle is the lack of reliable electricity, which is essential for implementing ICT and ensuring a stable internet connection (Gonfa et al., 2024). The barriers that hinder ICT integration, according to some studies, include limited access to technological tools and inadequate infrastructure, such as computers, internet connectivity, software, and hardware resources (Gonfa et al., 2024; Kaur, 2023; Othman et al., 2024). Limited access to high-speed internet, stemming from inadequate broadband infrastructure, hinders many rural communities from benefiting fully from ICT services (Melhem & Jacobsen, 2021). The high costs associated with ICT equipment and maintenance, coupled with poor transport infrastructure, further compound these challenges by restricting the reach and long-term sustainability of ICT initiatives (Mangundu et al., 2025). Therefore, efforts to integrate ICT in education are often unsustainable if these foundational infrastructural issues remain unaddressed.

Impact of implementing ICT in education

While using ICT in the classroom enhances teaching and learning, it can also have negative impacts. Lepp et al. (2019) asserted that the negative impact of multitasking on students' academic performance is evident in both online and face-to-face classes. Concurring with these findings, Nabung (2024) found that the use of digital tools can lead to multitasking that often becomes a source of distraction to students and undermines the quality of the learning experience. Löhr (2023) revealed that technology can disrupt not only social behaviour but also fundamental norms such as appropriate classroom conduct. Similarly, Kardi et al. (2023) found that digital technologies disrupt daily lives and institutional environments. This supports the notion that there is significant distraction in schools caused by using ICT devices for non-academic activities during teaching and learning (Flanigan & Babchuk, 2022; McGarr, 2024). Pérez-Juárez et al., (2023) recommended shifting teaching strategies and models to raise students' awareness of the significantly adverse effects of these digital distractions on their performance, as well as to develop their self-control skills. Therefore, it is essential to guide and educate learners about the potential distractions ICT can pose in educational settings.

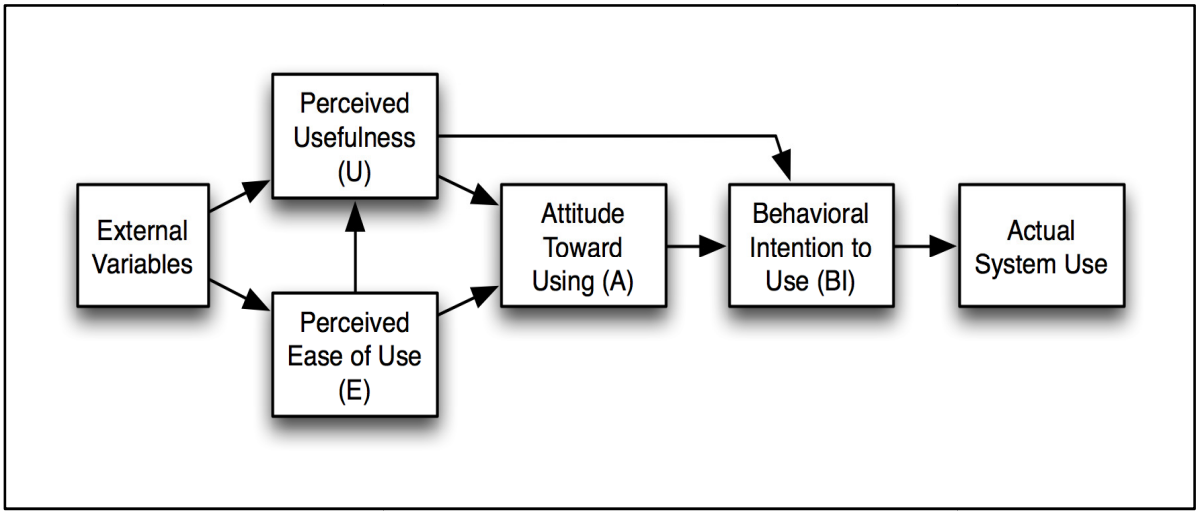
The use of digital technologies in education can create digital inequality for those learners without access to digital tools. Often, students from low-income families and marginalised groups lack adequate access to digital technologies and this leads to poor performance and

low academic achievement (Ajani, 2024). Additionally, learners without access to technological tools will miss out on acquiring the digital skills that are essential to 21st century education (Mushimiyimana et al., 2025). Therefore, schools should devise strategies to close this gap to ensure inclusive and equitable educational practice.

Theoretical framework

To better understand factors influencing the integration of ICT in Bushbuckridge schools, we employed the Technology Acceptance Model (TAM) as its theoretical perspective. TAM is used widely to examine individuals' acceptance and use of technology, particularly in educational settings (Granić, 2022). It centres on two key constructs: *perceived usefulness* (PU), which refers to "the extent to which an individual believes that using a particular technology will improve their job performance", while the *perceived ease of use* (PEOU) refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). TAM relates to the belief that using technology will require minimal effort. Figure 1 depicts the Technological Acceptance Model.

Figure 1
Adapted Technology Acceptance Model (TAM) from (Davis et al., 1989).



The use of TAM in this study is appropriate since it not only helps to assess perceptions but also provides a framework for understanding how infrastructural limitations shape behaviour and attitudes towards technology acceptance. Therefore, it moves beyond simply identifying whether schools have access to ICT and delves into how and why teachers decide to use or avoid using it. TAM enables a more nuanced examination of the human and contextual factors that influence the adoption of technology in under-resourced educational settings (Venkatesh & Davis, 2000). Using TAM in this study enabled us to interpret the findings from a perspective that connects both infrastructure and individuals thus providing a comprehensive understanding of the relationship between and among them.

Methodology

Study Design

This study is part of a larger research project that explores the challenges associated with adopting ICT in selected schools. This component of the study employed a qualitative approach to explore the infrastructural challenges that hinder the integration of ICT in schools and to propose strategies to enhance ICT integration in teaching and learning.

Study setting

As noted above, this study was conducted in the Bushbuckridge area of Mpumalanga Province, South Africa. The Mpumalanga Province, primarily known for its agricultural focus and activities, is divided into four educational districts, namely, Ehlanzeni Educational District, Nkangala Educational District, Gert Sibande Educational District, and Bohlabela Educational District. The Bohlabela district faces several challenges that have a negative impact on education and on the overall well-being of learners. It is known as the underperforming district in the province because of several challenges that are experienced in most of its schools.

Population and sampling

We selected twenty participants from 3 primary and 2 secondary schools. The sample consisted of fifteen teachers and 5 Heads of Department (HODs). The selection criteria included only those in senior management roles and those teachers who actively use ICT in their teaching practice. The sampling strategy was to interview 1 HOD and 5 teachers per school. Teachers and HODs were chosen to represent the diversity and educational challenges in the Bohlabela district, which is known for academic underperformance. We employed a purposeful sampling strategy to gather data on the infrastructural challenges that hinder the integration of ICT in rural schools. These teachers deal with everyday issues in the classroom, including the integration of ICT, so data saturation was reached with 20 participants. Accordingly, the use of purposive sampling helped to target only participants with relevant information since they dealt with complex issues daily in their schools and/or classrooms.

Data collection methods

Data was collected using a standardised interview guide. Face-to-face or remote interviews were conducted, depending on participants' preferences and logistical factors such as distance and availability. We used telephonic interviews for those who preferred to be interviewed remotely. Different interview guides were used for the different groups of participants, i.e., HODs and teachers, to address their unique perspectives. To ensure clear communication, the interviews were conducted in either the participants' vernacular language or in English, depending on their preference. To minimise potential interruptions and to enhance the

accuracy of the data collection process, we obtained permission to record the interview sessions digitally.

Data analysis

After gathering all the data, we reviewed the recordings and transcribed the interviews for analysis. We used thematic analysis to interpret the transcribed data, following the six-step process outlined by Braun and Clarke (2006). This process involved becoming familiar with the data, generating initial codes, searching for patterns, reviewing the identified themes, defining and naming those themes, and producing a detailed report. Through thematic analysis, key themes and patterns emerged that provided insights into the infrastructural challenges that hinder the integration of ICT in schools in Bushbuckridge.

Ethical consideration

Ethical approval was obtained from the UNISA College of Education Ethics Review Committee.[1] Gatekeeper permission to conduct the study was secured from the Mpumalanga Department of Education, Bohlabela District, and school principals from each participating school. The purpose and objectives of the study were outlined clearly to participants before the interview began. At that point, they signed an informed consent form to indicate their voluntary agreement to participate in the study.

Findings

The study's findings provide insight into the challenges participants face in integrating ICT into their teaching practices. It revealed the infrastructural and systemic complexities that impede the digital transformation of the education sector and offers important insights into the challenges facing educators in such contexts. The integration of ICT in schools requires not only teacher readiness and willingness but also a supportive institutional infrastructure to ensure its effective implementation. However, the study revealed that several infrastructural challenges continue to hinder the seamless integration of ICT in schools in the Bushbuckridge Local Municipality. These challenges are multi-layered and interconnected and reveal systemic barriers that require urgent attention if we are to facilitate the advancement of ICT integration. These findings present the profile of the participants, as well as the main findings of the study: insufficient ICT hardware and software infrastructure; poor maintenance of ICT hardware and software infrastructure; ailing electricity infrastructure; and theft and vandalism of ICT infrastructure.

Profile of the participants

The participants in this study included teachers with different teaching qualifications: Advanced Certificate in Education (ACE); Teaching Diploma (TD); Postgraduate Certificate in Education (PGCE); Bachelor of Education (B.Ed.); and Bachelor of Education Honours (B.Ed. Hons). Although all participants were trained for their teaching positions, none of

1 Ethics approval number: 21/09/08/64032264/25/AM

them held a master's degree or a PhD. The senior management team members, particularly the HODs, had at least 10 years of teaching experience.

The study participants were experienced teachers holding departmental leadership roles, with teaching experience ranging from six to 30 years. There were only two participants who were new teachers with less than five years of teaching experience, but they had been exposed to ICT in their teaching. The age of the participants ranged from 22 to 60 years, and all participants were currently employed in schools in Bushbuckridge, Mpumalanga Province, South Africa. The likelihood of willing participation was used as a selection criterion. Teachers and members of the senior management team, such as HODs, were interviewed using a semi-structured questionnaire that allowed for flexibility and follow-up on questions to gain further insights. This enabled us to collect of a wealth of information from the participants. Table 1 below highlights the participants' characteristics.

Table 1
Brief illustration of the profile of the participants

Participants	Schools and School Type	Qualifications	Gender	Age	Teaching Experience
Participant A1	School A	PGCE	F	31	6 years
Participant A2	(Primary school)	PGCE	F	45	20 years
Participant A3		B.Ed. Hons	F	37	9 years
HOD (1)			M	48	25 years
Participant B1	School B	ACE	M	44	25 years
Participant B2	(Secondary school)	ACE	M	47	30 years
Participant B3		TD	F	43	20 years
HOD (2)		TD	M	44	25 years
Participant C1	School C	B.Ed.	M	26	6 years
Participant C2	(Secondary school)	B.Ed.	F	30	5 years
Participant C3		B.Ed.	F	28	8 years
HOD (3)		ACE, B.Ed. Hons	M	35	12 years
Participant D1	School D	PGCE	F	25	2 years
Participant D2	(Primary school)	ACE	F	38	20 years
Participant D3		PGCE	F	30	6 years
HOD (4)		TD	F	56	30 years
Participant E1	School E	TD	M	39	17 years
Participant E2	(Primary school)	ACE	M	40	24 years
Participant E3		TD	F	49	27 years
HOD (5)		TD	F	57	30 years

ICT hardware and software infrastructure

The first finding is the inadequacy of ICT infrastructure (software and hardware). Participants reported that the ICT hardware, such as computers, projectors, and smartboards, was either insufficient or of poor quality. They raised concerns about the nonexistence of Learning Management Systems (LMS) as enablers of effective teaching and learning in schools, with

some schools having no or limited access. The provision of ICT hardware and software is primarily the responsibility of schools. However, participants reported that such resources were either lacking or insufficient. The unavailability of such essential ICT tools presents a significant barrier to the effective integration of ICT in schools. Moreover, participants mentioned that the lack of access to personal ICT devices, such as computers, laptops, and tablets further exacerbated the challenges associated with ICT integration. Teachers who were willing to integrate and use ICT in teaching and learning mentioned that the institutional learning environments did not support such initiatives. As Participant D1 noted,

> We are willing to use ICT in the classroom, but because of limited access to gadgets, we are unable to. We only have two computers in our school, which are kept in the principal's office. This is not enough to cover everybody.

This assertion suggests that teachers are willing to be innovative and transform learning and teaching practices. However, they feel constrained and demotivated because they are not provided with the necessary tools that schools must provide. Participants expressed frustration with the state of ICT facilities, noting that even when devices were available, they were often outdated, malfunctioning, or lacked technical support. The mere presence of ICT hardware does not guarantee its practical use. The scarcity or dysfunction of essential ICT tools, which form the foundation for effective digital teaching and learning disadvantages both students and teachers.

Maintenance of the ICT infrastructure

The second finding of the study relates to the poor maintenance of the ICT infrastructure. Participants from schools equipped with ICT hardware reported that most of the equipment was dysfunctional and needed repair. However, because of insufficient funds, these schools were unable to maintain the ICT equipment or fix it when it needed maintenance. This limitation hindered both teachers and learners severely from utilising modern technologies for teaching and learning purposes. The absence of funds suggests that the Department of Basic Education (DBE) and School Governing Bodies (SGBs) do not prioritise the integration of ICT into teaching and learning. These challenges must be addressed so that learners and teachers can acquire the necessary digital skills for the current learning and teaching environment.

Besides hardware challenges, participants also reported that the unreliability of the internet connection was another primary concern regarding the integration of ICTs. Slow and unreliable network connections were mentioned by teachers as significant constraints to the integration of ICTs in schools. Educators cited frequent disruptions, slow speed, and complete outages as significant constraints in integrating ICT into daily instructional practice. The ineffective internet connection hampered the use of ICTs in the classroom. Without a stable internet connection, teachers are unable to integrate effectively various technologies into their teaching and learning activities. Teachers did not know whether the unreliability of the internet was a result of the schools' failure to pay the network service providers or the providers' inability to repair it when it broke down.

Electricity infrastructure

The third finding was the ailing electricity infrastructure. While schools were connected to the electrical grid, the reliability of the electricity supply was a major challenge. Participants cited this as a significant obstacle to ICT integration in schools. The challenge of inadequate electricity supply is not unique to Bushbuckridge schools but is a nationwide problem in South Africa. Regular power outages, commonly referred to as load-shedding in the South African context, were reported as significant disruptions to teaching and learning since they disable ICT tools. It is worth noting that load shedding is no longer as frequent as it was during the study. In some cases, these interruptions were exacerbated by infrastructure issues, such as cable theft, which prolonged disconnection from the grid. The instability of the electricity supply renders it difficult for teachers to operate computers in classrooms and impedes the integration of ICTs. Instances of power cables being stolen further exacerbate the problem, resulting in frequent disconnections from the electricity supply. Overall, the lack of access to reliable electricity hampers significantly the integration of ICTs in schools.

Theft and vandalism of ICT infrastructure

The fourth finding pertains to the theft and vandalism of ICT infrastructure as factors contributing to the lack of ICT infrastructure. Some schools in Bushbuckridge do their best to provide the necessary ICT infrastructure, but the secondary challenge of theft and vandalism makes this impossible. Participant B2 said,

> Although schools are vulnerable to crime and always spend a lot to beef up security by installing security cameras, we are not willing to adopt technologies in our school because they get stolen.

These findings link directly to the previously reported lack of funding which results in insufficient resources in relation to security. Additionally, security measures are not prioritised by either the DBE nor SGBs and leaving schools vulnerable to criminal activity exacerbates the problem. Consequently, schools become targets for criminals and vandals, further jeopardising the safety of the ICT infrastructure. Strengthening collaboration between schools and communities is essential to prevent theft and vandalism and thus ensure the protection of school infrastructure.

The lack of digital infrastructure and facilities highlights four key issues that hinder ICT integration in teaching and learning: insufficient ICT hardware and software infrastructure that is compounded by poor maintenance; theft and vandalism of ICT infrastructure; and an unreliable electricity supply. Collectively, these challenges impede the effective utilisation of ICTs in schools. Our findings emphasise the necessity for multi-stakeholder intervention involving community members, civil organisations, school governing bodies, and government entities to address these complex challenges comprehensively.

Discussion

Our study explored the infrastructural challenges that hinder the integration of ICT in schools located in the Bushbuckridge area of Mpumalanga Province. It revealed that one of the most pressing obstacles to the integration of ICT is the inadequacy of both hardware and software infrastructure. This deficiency reflects a deeper issue of infrastructural neglect in under-resourced schools. Unfortunately, even if teachers want to use these ICT tools, they cannot because they do not exist. Consequently, this creates a contradictory situation in that PU is the opposite of PEOU. Once this happens, the attitude towards using is affected negatively. Naaz (2025) asserted that, even where teachers exhibit a strong willingness to adopt ICT, their efforts are constrained by institutional shortcomings such as infrastructural inadequacies, inconsistent institutional support, and insufficient professional development, all of which hinder effective integration. The absence of educational software in under-resourced schools hampers teaching efficacy. This supports the view of Zou et al. (2025) that hardware and software limitations remain key barriers to the successful integration of ICT.

This finding highlights the digital divide that extends beyond technology to encompass pedagogy. The lack of functional ICT resources undermines teachers' PU and PEOU of technology. Teachers' enthusiasm is thus met with structural resistance, which results in diminishing the feasibility of ICT adoption in practice. Habibi et al. (2023) argued that the digital gap further entrenches educational inequality. Addressing this requires more than just the provision of devices; it calls for deliberate investment in infrastructure and an inclusive digital policy regime. Similarly, Ngodu et al. (2024) emphasised the need for systemic reforms to enhance ICT accessibility and usability. This finding demonstrates that without meaningful support and targeted planning, the promise of digital education will remain unrealised. Teachers' intention and capacity to innovate are clear, but their environments must support this transformation.

The second finding is the poor maintenance and dysfunctionality of ICT infrastructure in schools that hampers significantly the integration of digital technologies into teaching and learning. Poor maintenance is attributed to insufficient funds from the schools, resulting in the failure to maintain or repair broken ICT tools. This situation renders the ICT tools unusable, limiting their potential benefits and affordances. This condition aligns with the point made by Lin (2024), in asserting that daily maintenance and updating of equipment is vital for the effective use of ICT in educational settings. These findings suggest that the lack of maintenance funding reflects the broader systemic issue of the apparent lack of prioritisation of ICT integration by both DBE and SGB since continual investment in maintenance, upgrades, and technical support is essential for proper ICT integration. Without reliable internet access, the use of educational platforms, online content, and communication tools becomes impracticable, further impeding the potential benefits of digital teaching methods. Dysfunctional internet infrastructure, therefore, directly undermines the PU and PEOU.

The third finding highlights the profound barrier posed by an unreliable electricity supply. Although all schools that participated in this study had access to electricity, its supply was frequently unstable. The intermittent availability of electricity has a negative impact on ICT integration. This finding is consistent with that of Gonfa et al. (2024), who asserted that a country's ability to build its ICT infrastructure is reliant on its ability to secure a steady supply of electricity. Inadequate power not only reduces the PU and PEOU, but also discourages teachers from relying on ICT in their pedagogical practices.

This challenge reflects a broader national crisis. South Africa's deteriorating electrical infrastructure, characterised by chronic underinvestment and frequent load shedding, has hindered educational and socio-economic progress (Pitikoe-Chiloane & Dondolo, 2024). Participants noted that such instability affects rural schools disproportionately and this further deepens the digital divide. In their study, Maphalala and Adigun (2020) found that rural universities often lack robust ICT infrastructure, including reliable internet connectivity and electricity. Some of these factors are interdependent since, for example, unstable electricity directly and indirectly disrupts internet access, making digital learning impossible. These disruptions hinder progress toward South Africa's vision for the Fourth Industrial Revolution, particularly in under-resourced regions such as Bushbuckridge. Although ICT resources may be present in schools, their impact is severely limited without reliable electricity (Gonfa et al., 2024).

The fourth finding relates to the theft and vandalism of digital infrastructure in schools. Although some schools in Bushbuckridge have made strides in acquiring ICT tools, frequent instances of theft and vandalism have rendered much of this infrastructure unusable. These ongoing crimes threaten ICT sustainability (Mangundu et al., 2025). The challenge is compounded by limited funding, which restricts schools' ability to deploy adequate security personnel (Ekpoh et al., 2020). Most schools cannot afford surveillance systems or dedicated security personnel, leaving ICT resources vulnerable. (Alabdali et al., 2023) have argued that the cost of technology and the expense of protecting it remain significant barriers to ICT adoption in low-resource settings.

The impact of this insecurity is twofold. First, the loss of ICT tools reduces their PU since educators are unable to rely on consistently available resources. Second, it diminishes their behavioural intention to integrate technology into teaching. Munje and Jita (2020) have noted that repeated disruptions caused by crime contribute to broader educational and social inequalities. Stronger collaboration between and among schools, communities, and local businesses is necessary to address these challenges. Volunteer safety programmes and local partnerships can help safeguard resources (Mangundu et al., 2025). This approach is consistent with Sithole and Mbukanma's (2024) assertion that targeted infrastructure development and context-specific solutions are needed to ensure equitable access to ICT. Moreover, these scholars highlight the need for partnerships to adopt ICT effectively and the necessity of targeted interventions to address the challenges of infrastructure development and capacity building.

As schools adopt ICT tools, they collect sensitive student records, health data, academic performance data, and even biometrics. Consequently, data protection and privacy concerns have become critical issues that must be addressed proactively. Addressing data protection and privacy demands a robust, multi-layered defence that integrates technical controls (e.g., firewalls, antivirus protection, encryption, access controls), administrative policies, and continual cybersecurity training to mitigate effectively modern cyber threats in educational environments (Djeki et al., 2024; Watini et al., 2024). Additionally, the DBE should allocate funds across infrastructure development, maintenance, training, and digital access. Haleem et al. (2022) argued that educator confidence, skills, and training are essential for effective ICT integration. A secure, well-resourced environment is thus critical for realising the transformative potential of educational technology.

Conclusion and implications

In this study, we highlight the critical infrastructural barriers hindering effective ICT integration in schools across Bushbuckridge in Mpumalanga Province. Key study findings include insufficient ICT hardware and software infrastructure, poor maintenance of what there is, an ailing electricity infrastructure, and persistent theft and vandalism of ICT infrastructure. These challenges limit severely teachers' ability to use digital tools and they deprive learners of essential 21st-century digital skills. Despite teachers' willingness to adopt technology, insufficient infrastructure undermines the potential of ICT to enhance education. These findings underscore the need for urgent and coordinated efforts among the DBE, local communities, and private stakeholders to invest in and sustain ICT infrastructure. This includes addressing funding gaps, improving security through community involvement and surveillance systems, and ensuring stable electricity and, therefore, internet access. Investment must be geared towards enhancing digital infrastructure and teacher readiness to help bridge the digital divide. By doing so, schools in under-resourced areas, such as Bushbuckridge, can improve digital proficiency and academic performance with targeted investment and sustained support.

Acknowledgements

We thank all the respondents who shared generously their time, experiences, and insights, all of which were invaluable to this research. We acknowledge the use of an AI language model developed by OpenAI for language editing. We have reviewed the final content and verified it to ensure accuracy and originality.

References

Ajani, O. A. (2024). Exploring digital transformation and future trends in higher education development across African nations. *Journal of Pedagogical Sociology and Psychology*, 6(*3*), 34–48. https://doi.org/10.33902/jpsp.202427374

Alabdali, S. A., Pileggi, S. F., & Cetindamar, D. (2023). Influential factors, enablers, and barriers to adopting smart technology in rural regions: A literature review. *Sustainability*, 15(*10*), 1–30. https://doi.org/10.3390/su15107908

Alenezi, M., Wardat, S., & Akour, M. (2023). The need of integrating digital education in higher education: challenges and opportunities. *Sustainability*, 15(*6*), 1–12. https://doi.org/10.3390/su15064782

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bushbuckridge Local Municipality. (2023). *Bushbuckridge Local Municipality Final Integrated Development Planning 2023/24*. https://www.bushbuckridge.gov.za/images/files/2024/06/20/671/FINAL_IDP_2024-25.pdf

Chisango, G., & Marongwe, N. (2021). The digital divide at three disadvantaged secondary schools in Gauteng, South Africa. *Journal of Education*, 82, 149–165. https://doi.org/10.17159/2520-9868/i82a09

Costa, A. C. F., de Brito Silva, A. M., Espuny, M., Rocha, A. B. T., & de Oliveira, O. J. (2024). Toward quality education: Contributions of EdTech to the achievement of the fourth United Nations Sustainable Development Goal. *Sustainable Development*, 32(*3*) 1634–1651. https://doi.org/10.1002/sd.2742

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information. *MIS Quarterly*, 13(*3*), 319–340. https://doi.org/10.2307/249008

Djeki, E., Dégila, J., Bondiombouy, C., & Alhassan, M. H. (2024). *Data protection in digital learning space: An overview*. AIP Conference Proceedings. Glasgow, UK. https://doi.org/10.1063/5.0204895

Ekpoh, U. I., Edet, A. O., & Ukpong, N. N. (2020). Security challenges in universities: Implications for safe school environment. *Journal of Educational and Social Research*, 10(*6*), 112–124. https://doi.org/10.36941/jesr-2020-0113

Flanigan, A. E., & Babchuk, W. A. (2022). Digital distraction in the classroom: Exploring instructor perceptions and reactions. *Teaching in Higher Education*, 27(*3*), 352–370. https://doi.org/10.1080/13562517.2020.1724937

Gonfa, M. H., Birhanu, A. L., & Gendo, K. M. (2024). Review on practice and challenges of ICT integration as pedagogical tools in Ethiopian primary school curriculum implementation. *Discover Education*, 3(*1*). https://doi.org/10.1007/s44217-024-00184-w

Granić, A. (2022). Technology acceptance and adoption in education. *Handbook of Open, Distance and Digital Education*. 1–15). https://doi.org/10.1007/978-981-19-0351-9_11-1

Habibi, A., Sofyan, S., & Mukminin, A. (2023). Factors affecting digital technology access in vocational education. *Scientific Reports*, 13(*1*). https://doi.org/10.1038/s41598-023-32755-6

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Kardi, K., Basri, H., Suhartini, A., & Meliani, F. (2023). Challenges of online boarding schools in the digital era. *At-Tadzkir: Islamic Education Journal*, *2*(*1*), 37–51. https://doi.org/10.59373/attadzkir.v2i1.11

Kaur, K. (2023). Teaching and learning with ICT tools: Issues and challenges. *International Journal on Cybernetics & Informatics*, 12(*3*), 15–22. https://doi.org/10.5121/ijci.2023.120302

Lepp, A., Barkley, J. E., Karpinski, A. C., & Singh, S. (2019). College students' multitasking behavior in online versus face-to-face courses. *SAGE Open*, 9(*1*), 1–9. https://doi.org/10.1177/2158244018824505

Lin, Y. (2024). Application and challenges of computer networks in distance education. *Computing, Performance and Communication Systems*, 8(*1*), 1–8. https://doi.org/10.23977/cpcs.2024.080103

Löhr, G. (2023). Conceptual disruption and 21st century technologies: A framework. *Technology in Society*, 74. https://doi.org/10.1016/j.techsoc.2023.102327

Lomo, D. A., Abonyi, U. K., & Ahwireng, D. (2025). Headteachers' support and challenges toward ICT integration into teaching and learning in Ghanaian basic schools. *Leadership and Policy in Schools*, 24(*2*), 330–345. https://doi.org/10.1080/15700763.2024.2317300

Mangundu, J., Makwara, C., & Thaba-Nkadimene, K. (2025). Barriers to sustainable integration of ICT in Pietermaritzburg public secondary schools. *International Journal of Research in Business and Social Science*, 14(*2*), 342–351. https://doi.org/10.20525/ijrbs.v14i2.3856

Maphalala, M. C., & Adigun, O. T. (2020). Academics' experience of implementing e-learning in a South African higher education institution. *International Journal of Higher Education*, *10* (*1*), 1–13. https://doi.org/10.5430/ijhe.v10n1p1

McGarr, O. (2024). Teacher educators' views and responses to digital distraction in pre-service teacher education. *Teaching and Teacher Education*, 148. https://doi.org/10.1016/j.tate.2024.104701

Melhem, S., & Jacobsen, A. H. (2021). *A global study on digital capabilities*. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/959181623060169420/a-global-study-on-digital-capabilities

Mhlongo, S., Mbatha, K., Ramatsetse, B., & Dlamini, R. (2023). Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review. *Heliyon*, 9(*6*), 1–20. https://doi.org/10.1016/j.heliyon.2023.e16348

Mkhonto, B. S., & Mubangizi, B. C. (2024). Digital divide or digital bridge? evaluating the impact of ICT integration in South Africa's rural schools. *International Journal of Social Science Research and Review*, 7(*7*), 132–145. https://doi.org/10.47814/ijssrr.v7i7.2142

Munje, P. N., & Jita, T. (2020). The impact of the lack of ICT resources on teaching and learning in selected South African primary schools. *International Journal of Learning, Teaching and Educational Research*, 19(*7)*, 263–279. https://doi.org/10.26803/IJLTER.19.7.15

Mushimiyimana, J. B., Nzabalirwa, W., Ndayambaje, I., & Lazareva, A. (2025). ICT integration in Rwandan education: A scoping review of opportunities and challenges. *African Journal of Empirical Research*, 6(*1*), 225–234. https://doi.org/10.51867/ajernet.6.1.21

Naaz, F. (2025). Enhancing ICT integration: Addressing teachers' perspectives and institutional challenges in schools. *Synergy: International Journal of Multidisciplinary Studies*, *2(1)*, 61–72. http://creativecommons.org/licenses/by/4.0/.Article

Nabung, A. (2024). The impact of multitasking with digital devices on classroom learning: A critical review on the future of digital distraction in education. *US-China Education Review A*, 14(*6*), 1–15. https://doi.org/10.17265/2161-623x/2024.06.005

Ngodu, A., Ndibalema, P. M., & William, F. (2024). Understanding stakeholders' perception on integrating ICT in teaching and learning science subjects: Experiences from Tanzanian secondary schools. *Educational Technology Quarterly*, 2024(*3*), 275–297. https://doi.org/10.55056/etq.714

Othman, W., Makrakis, V., Kostoulas-Makrakis, N., Hamidon, Z., Keat, O. C., Abdullah, M. L., Shafie, N., & Mat, H. (2024). Predictors of motivation and barriers to ICT-enabling education for sustainability. *Sustainability*, 16(*2*), 1–13. https://doi.org/10.3390/su16020749

Pérez-Juárez, M. Á., González-Ortega, D., & Aguiar-Pérez, J. M. (2023). Digital distractions from the point of view of higher education students. *Sustainability*, 15(*7*), 1–22. https://doi.org/10.3390/su15076044

Pitikoe-Chiloane, G. M., & Dondolo, H. B. (2024, June 13–17). *The impact of electricity blackouts on academic activities in South African higher institutions* [Conference session]. The Paris Conférence on Education. Paris, France. https://papers.iafor.org/proceedings/conference-proceedings-pce2024/

Ramorola, M. Z. (2013). Challenge of effective technology integration into teaching and learning. *Africa Education Review*, 10(*4*), 654–670. https://doi.org/10.1080/18146627.2013.853559

Saba, C. S., Ngepah, N., & Odhiambo, N. M. (2023). Information and Communication Technology (ICT), growth and development in developing regions: Evidence from a comparative analysis and a new approach, 15, 14700–14748. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-023-01571-8

Saba, C. S., Ngepah, N., & Odhiambo, N. M. (2025). The nexus between ICT diffusion, financial development, industrialization and economic growth: Evidence from sub-Saharan African countries. *Journal of African Business*, 26(*2*), 454–478. https://doi.org/10.1080/15228916.2025.2451550

Salam, S., Zeng, J., Pathan, Z. H., Latif, Z., & Shaheen, A. (2018). Impediments to the integration of ICT in public schools of contemporary societies: A review of literature. *Journal of Information Processing Systems*, 14, (*1*), 252–269. https://doi.org/10.3745/JIPS.04.0062

Sithole, V. L., & Mbukanma, I. (2024). Prospects and challenges to ICT adoption in teaching and learning at rural South African universities: A systematic review. *Research in Social Sciences and Technology*, 9(*3*), 178–193. https://doi.org/10.46303/ressat.2024.54

Venkatesh, V., & Davis, F. D. (2000). Theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(*2*), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Watini, S., Davies, G., & Andersen, N. (2024). Cybersecurity in learning systems: data protection and privacy in educational information systems and digital learning environments. *International Transactions on Education Technology (ITEE)*, 3(*1*), 26–35. https://doi.org/10.33050/itee.v3i1.665

Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: Trends, challenges, and innovations in technology integration. *Frontiers in Education*. https://doi.org/10.3389/feduc.2025.1562391