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The role of ICT integration on primary school learners' cognition: A rural education perspective

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ABSTRACT

Using the cognitive theory as a framework, this paper examines the ways in which the integration of Information and Communication Technology (ICT) in teaching and learning contributes to and supports content understanding among rural primary school learners. ICT plays a transformative role by altering traditional teaching methods and reshaping how learners engage with content. In rural educational settings, however, schools often face numerous contextual challenges, including inadequate physical infrastructure, limited computer access, insufficient educational programs, and unreliable internet connectivity. Despite these limitations, when integrated thoughtfully into an ICT-enabled curriculum, technology holds significant potential to transform instructional practices, accelerate learning processes, enhance skills acquisition, and deepen learners' comprehension of academic content.

The study was conducted through an interpretivist lens, employing a qualitative research methodology and a case study design. Data were gathered from six teachers teaching different subjects across three selected rural primary schools. The collected data were analysed using thematic analysis to identify emerging patterns and insights. The findings demonstrate that the integration of ICT into the teaching and learning process plays a crucial role in enhancing learners' cognitive development, ultimately leading to improved academic performance. Based on these findings, the study advocates for the provision and effective implementation of ICT-enabled education in rural primary schools to promote the cognitive growth and academic success of learners, even in the face of contextual challenges that characterize many rural educational environments.

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INTRODUCTION

The incorporation of new technologies and media offers opportunities for strengthening teaching and learning, although the extent of impact depends on contextual factors, such as teacher preparedness, resource availability, and pedagogical approaches. The integration of Information and Communication Technology (ICT) reflects a global call for teachers to enhance instruction through technology-based teaching and learning tools. In view of the foregoing, this article argues that integrating ICT into teaching enhances learners' understanding of content and improves their academic outcomes. Technological advancements have consistently supported new approaches to teaching and learning. When implemented accurately, technological applications for pedagogical use appear to have a positive impact on learners' understanding of subject content. ICT in education refers to the use of computer-based technologies that are integrated into daily classroom teaching and learning processes. Ghavifekr and Rosdy (2015) state that the pedagogical use of technology in education leads to effective learning in almost all subjects. Furthermore, ICT provides this balancing support that supplements effective teaching and learning. In enhancing learning cognition, Susilawati and Supriyatno (2023) assert that the integration of ICT in learning fosters the development of learners' critical thinking skills, encourages independence, and supports problem-based learning. ICT integration provides a considerable shift of the learning environment to a learner-centred type of learning, as ICT enables teachers to design lesson plans that encourage active and participatory learning. Kibirige (2023) further states that integrating ICT in primary school subjects helps learners understand abstract concepts, as they are still developing their knowledge and basic skills.

Compared to their urban counterparts, schools in rural contexts often face several challenges that hinder the integration and effective implementation of ICT. These challenges can lead to significant gaps in access to quality education. Some of these challenges may include limited infrastructure and connectivity, limited teacher skills and professional development, inadequate technical support, and geographical isolation, among others (Kennedy, 2023; Karunakaran & Dhanawardana, 2023; Kibirige, 2023). ICT integration in rural schools is hindered by multiple challenges, including inadequate infrastructure, limited funding, lack of teacher training, and socio-economic barriers (Joshi & Ayer, 2024). These challenges hinder rural schools from fully harnessing the potential of technology in teaching and learning, thereby widening the educational gap between rural and urban areas. To overcome these challenges, targeted policies, increased investment, and customized solutions are needed to promote equitable access to ICT resources and support within rural communities. Based on this introduction and background, this paper responds to the following question: How does ICT integration enhance learners' cognition?

The role of Information and Communication Technologies (ICT) in school education cannot be overemphasised. However, the use of the Internet has not yet become a broadly followed practice in the South African rural educational context. Most of the teaching and learning that is provided to primary school learners is not computer-based. Cassim (2010) argues that, although teachers recognise the importance of ICT in teaching and learning, systemic challenges limit the pedagogical integration of ICT in South African schools. Some of the systemic challenges include the current traditional education curricula (Enaifoghe et al., 2021). Research highlights persistent barriers to ICT integration in education, including a lack of resources and structural design challenges within existing systems (Meyer et al., 2017), as well as the tendency to prioritise technological possibilities over the actual educational needs of learners (Susilawati & Supriyatno, 2023). Against this backdrop, this paper argues that, when thoughtfully implemented, integrating ICT into teaching and learning has the potential to enhance the cognitive development of primary school learners. In addition to preparing learners for the current digital era, teachers, who play a central role in integrating ICT into daily classroom practices, are responsible for ensuring that the use of ICT enhances learners' academic outcomes.

Generally, in rural primary schools, most learning is not computer-based. Despite efforts to integrate technology into education, challenges such as limited access to devices, inadequate infrastructure, and insufficient teacher training persist, hindering the widespread adoption of digital learning tools. Power et al. (2020) assert that issues of inequity persist, with rural schools often at the receiving end of this inadequacy. The authors further indicate that rural schools typically face challenges related to computer access, outdated technology, and equipping teachers to utilise technology for pedagogical transformation. At this juncture, it is important to note that pedagogy precedes technology. Effective teaching and learning methods (pedagogy) should come before the integration of technology in education. This implies that technology should function as a tool to strengthen and enrich pedagogical approaches, rather than being the driving force behind them. Rural schools can utilise resources that are available to them to facilitate ICT integration into teaching and learning. Wang et al. (2022) suggest that school leadership plays a crucial role in ensuring that available ICT tools are effectively utilised within the school. This includes providing internet connectivity for teachers to use their smartphones and personal computers for teaching. Bernacki et al. (2020) assert that although the use of personal electronic devices in learning is a relatively new exercise, portable technologies can be effectively utilised to improve instruction delivery.

Nhlumayo (2024) indicates that ICT integration is not only about owning school computers but is about ensuring that every digital device in the school is used for the benefit of learners. Furthermore, attitudes play a vital role in integrating ICTs to improve learner cognition. When the school principals and the teachers' attitudes toward ICT integration are indifferent, the process of ICT integration suffers, thereby compromising the quality of education for learners. Through the integration of ICT into teaching and learning, learners' growth and development can be enhanced (Kilag et al., 2023). The authors further state that ICT integration improves learners' engagement and motivation in their respective subjects, and further improves their cognition without the teacher having to remind or narrate to them.

The advantages of integrating ICT into teaching include learners enjoying the learning process and collaborating, thereby contributing to their academic achievement (Kilag et al., 2023). Mpiti et al. (2023) state that in rural primary schools, ICT integration enables learners to participate during class and further facilitates the coordination of their social surroundings throughout the learning process. For primary school learners, ICT integration enhances their social interaction, improves their creativity, and fosters interactivity and engagement in the learning process. Güney (2023) asserts that when schools are well-resourced with digital equipment, learners can access information, resources, and relevant subject content online that might not be found in traditional textbooks. With the world undergoing a technological transformation, learners must be exposed to new technologies and be afforded access to various digital equipment both in and outside of school. ICT integration enhances learning, makes the subjects appealing, and promotes the development of problem-solving, communication, research, and decision-making skills. These skills are being developed in primary school learners, as noted by Melieva (2023). ICT facilitates teaching and e-learning, thereby positively shaping learners' cognition alongside teaching practices. As Maja (2023) highlights, learners are increasingly more digitally enabled than adults, which calls for teachers to devise strategies that leverage digital instruction to enhance cognitive development and craft inclusive learning experiences, even in contexts where access to technology is uneven.

ICT integration in education not only enhances engagement, motivation, and personalised learning but also strengthens learners' cognition while equipping them with essential skills for their future careers. It empowers both teachers and learners with tools to enhance cognitive and learning outcomes, facilitate effective collaboration, and access a vast world of information. Fernández-Gutiérrez et al (2020) indicate that one of the key benefits of integrating ICT into teaching and learning is the enhancement of learners' academic outcomes. When used effectively, in underprivileged contexts, ICT can help bridge the digital divide, providing underprivileged learners access to high-quality learning resources that may otherwise be unavailable. Furthermore, ICT integration enables learners in remote or underserved areas to access education, thereby levelling the playing field for those who might otherwise have limited opportunities.

Resonating with this view are Dakhi et al (2020), who state that ICT integration can enhance learners' access and flexibility, develop effective learning levels, and achieve better learner experiences and outcomes. In Elbanna and Armstrong's (2024) study on adapting ChatGPT for the future of learning, the findings suggest that when Artificial Intelligence (AI) tools are effectively integrated into teaching and learning, they have a positive impact on educational outcomes for learners at all levels of education.

In rural areas where technology is often limited or unreliable, effective pedagogy ensures that learning can continue without digital tools. Pedagogy centres on the quality of education, while technology is a complementary resource that supports and enhances this quality. Teachers may have access to the latest technological resources; however, without a shift in their teaching philosophy, genuine transformation in the classroom cannot occur.

This paper is grounded in cognitive theory. Proposed by Jean Piaget, cognitive theory examines how individuals acquire, organize, store, and retrieve information. In the classroom context, cognitivism promotes an environment that develops through interactive mental activities designed to stimulate learners' thinking abilities. Cognitive theory offers a useful framework for examining the role of ICT integration in enhancing primary school learners' cognition, especially in rural contexts. The theory highlights that learning is an active process whereby learners build knowledge through focused attention, perception, memory, and problem-solving. Within this framework, ICT can serve as a cognitive tool that scaffolds mental processes and supports higher-order thinking. By presenting content in multimodal formats, visual, auditory, and interactive, ICT has the potential to strengthen working memory, reduce cognitive overload, and promote deeper conceptual understanding. In rural schools, ICT further enables learners to engage actively with content through exploration, self-paced learning, and problem-solving tasks that nurture attention, organisation, and transfer of knowledge (Mngomezulu et al., 2024). These opportunities align with the cognitive theory principle that meaningful learning occurs when learners are mentally active and interact with their environment. However, the extent to which ICT fosters cognitive development depends on its pedagogical alignment with learners' developmental needs and its adaptation to contextual realities such as limited infrastructure and teacher preparedness. Thus, drawing on cognitive theory, this paper argues that the integration of ICT in rural classrooms can enhance learners' cognitive development, provided it is thoughtfully implemented to address contextual challenges.

OBJECTIVES OF THE STUDY

This study aims to investigate the impact of integrating Information and Communication Technology (ICT) on the cognitive development of primary school learners in rural educational settings. Although ICT is widely recognised for its potential to transform teaching and learning, its specific influence on learners' cognitive processes, including aspects such as critical thinking and problem-solving, as well as knowledge construction, remains underexplored in under-resourced rural settings. This study aims to examine how the integration of ICT tools and digital resources can support and stimulate cognitive engagement among rural primary school learners, despite infrastructural and contextual limitations. By adopting a rural education perspective, the study aims to contribute valuable insights into how ICT can be meaningfully implemented to foster equitable learning outcomes, bridge educational divides, and guide policy and practice in comparable socio-educational contexts.

METHODOLOGY

Guided by an interpretive qualitative paradigm, this paper employed a multiple case study design to generate data from the selected three rural primary schools within the same education district. The multiple case study design was not intended to compare learners' abilities to understand content, but rather to explain the cases and link them to understand how ICT integration can be used to enhance learners' cognitive abilities. From each school, two teachers took part in the study. Data was generated using open-ended

questions through in-person interviews with all six participants. To interview participants, the researcher obtained ethical clearance from their institution and permission from the school principals, as gatekeepers. The six teachers were purposively selected as teachers who implement the integration of ICT in teaching and learning and were the relevant participants to respond to the interview questions. Data were analysed using thematic analysis by identifying common themes in the participants' responses. Data triangulation was employed by using data from different individuals at various times and in different settings, as guided by Denzin (2012). The researcher ensured the trustworthiness of the findings through member checking by soliciting feedback from participants about the data generated. The following table provides a brief demographic outlook of the participants and the research sites.

Table 1. Profile of the research participants and research sites

Research sites	Number of learners in the school	Participants	Age	Qualifications	Grade Teaching	Number of years as a teacher
School A	458	Participant A	32	B.Ed. (Snr & FET Phase)	7	7
		Participant B	29	B.Sc. + PGCE	6	6
School B	316	Participant C	33	B.Ed. (Int. Phase)	4	10
		Participant D	42	B.Ed. (Int. Phase)	5	9
School C	322	Participant E	26	B.Ed. (Found Phase)	3	3
		Participant F	41	B.Ed. (Found Phase)	2	10

***Keys**: Snr-Senior, FET-Further Education and Training, Int-Intermediate, B.Ed.-Bachelor of Education, BA-Bachelor of Arts, B.Sc.-Bachelor of Science, PGCE-Postgraduate Certificate in Education*

Table 1 presents a concise demographic overview of the participants and research sites. Pseudonyms have been used to indicate participants in this paper.

From School A – Participant A and Participant B (PA and PB)
From School B – Participant C and Participant D (PC and PD)
From School C – Participant E and Participant F (PE and PF)

FINDINGS

Drawing on verbatim quotes from participants, the following sections present the key themes that emerged from the data. These themes are improvement in learners' understanding of content, enablers of ICT integration in teaching and learning in rural schools, enhancement of the learning environment, and increased learning motivation. These are presented in the following section.

Improvement in learners' understanding of content

When participants were asked to share their experiences of teaching with technology-based tools in the classroom, it became clear that learners displayed improved cognition during various assessment tasks. This phenomenon encouraged teachers to continue integrating ICTs into teaching and learning, as it yielded positive outcomes. This is what they shared:

I teach Technology in Grade 7, and I have struggled to explain concepts and drawings that are a requirement in the subject. However, once I showed learners these videos from the internet, I no longer faced any challenges; they could even create their freehand drawings based on what they saw. **PA**

The data revealed that learners enjoyed using computers in the classroom, which enabled them to retain all they had learned. A foundation phase teacher reiterated that learners' cognitive abilities improved when learning was computer-based. This was her view:

You know what? My kids remember everything we learned using the computer more than when the same thing is done on the chalkboard. I think they are more fascinated with the laptop. **PF**

My learners even want to stay behind after school so that we can do more schoolwork using the computer, and even their parents are positive about it because they can see the improvement in their schoolwork. **PD**

The data findings indicate that when ICT is effectively integrated into teaching and learning, it has the potential to enhance learners' cognitive abilities by supporting processes such as attention, memory, and problem-solving. Grounded in cognitive theory, which views learning as an active process of constructing knowledge, ICT tools can scaffold these mental processes, making learning more meaningful and yielding improved outcomes. Ghavifekr and Rosdy (2015) emphasise that ICT integration can take multiple forms, such as educational videos, that enrich cognitive engagement and make the learning process fulfilling for both teachers and learners. Similarly, Ngao and Sang (2024) note that learners become more cognitively receptive and active participants when ICT is employed to mediate learning. Even within traditional teaching approaches, Rapanta et al. (2021) argue that teachers need to balance content, pedagogy, and technology in ways that stimulate learners' cognition while also preparing them to adapt to the demands of a globalised and technologically driven society.

Enablers of ICT integration for enhancing learners' cognition in rural teaching and learning

In response to the question regarding the factors that facilitate ICT integration to enhance learners' cognition in rural schools, participants revealed that, although there are contextual factors, they have found ways to ensure that they integrate ICT into their teaching and learning for learners' cognition. One participant shared that they use their cell phone, data, and laptop to ensure that learners can tap into the ICT devices available to them.

I connect my laptop to my cell phone and teach my learners in groups, allowing them to learn using laptops; they become very excited. Our school does not have a computer lab or dedicated computers for learning; instead, we use our own, as it has been shown to be beneficial for both our learners and us. **PC**

Through the use of audio, images, videos, and texts, I have seen that my learners pay more attention than when I use the traditional teaching method. Because I would sometimes record a lesson using my cell phone and play the recording in class, the learners would become very attentive, and surprisingly, remember everything that was said in the recording. It is very fascinating. **PD**

Most rural schools face multiple deprivations in terms of ICT facilities and resources, including limited connectivity, a lack of computers and other devices, and the absence of computer laboratories. These constraints hinder the provision of technology-enhanced education, often forcing teachers to prioritise theoretical instruction over practical, hands-on learning experiences. Consequently, learners' opportunities to engage cognitively with content, through problem-solving, exploration, and interactive activities, are restricted, limiting the development of critical thinking, memory retention, and higher-order cognitive skills.

One participant revealed that they took their learners to the resource centre where they could learn using computers. She said:

Although it is usually once a month, we can visit the resource centre with my learners so that they can have their lessons presented through a computer and an interactive whiteboard instead of using chalk and a chalkboard. It is such a great achievement for us, and it is bearing fruit. **PE**

Sharing similar sentiments with PE, PF stated that using the communal resource centre has helped improve learners' academic outcomes. He said:

I have noticed a big difference since we started taking kids to the resource centre; it has also decreased the level of absenteeism, and they enjoy coming to school, but most of all, their understanding of the subject matter has increased. **PF**

Overall, ICT has become an essential component of teachers' everyday professional practices, as they are personally exposed to smartphones, smart televisions, and personal laptops. Teachers can leverage these ICT tools to facilitate learning without completely altering their existing instructional practices. These tools offer diverse ways to engage learners cognitively, supporting processes such as attention, memory, and comprehension. ICT integration allows teachers to enhance and expand their instructional approaches rather than abandoning them entirely (Saarinen et al, 2021). The data indicate that even limited use of ICT during teaching can have a positive influence on learners' understanding of content and promote cognitive development. Although many teachers have not received formal training in the use of ICT for teaching and learning (Nhlumayo, 2024), they often employ available technologies opportunistically to help learners actively process information and construct knowledge, thereby enhancing their cognition.

Enhancing learners' cognition through improved learning environments and increased motivation

The data indicate that learners valued even limited exposure to ICTs, which fostered enthusiasm, motivation, and a more dynamic learning environment. When effectively integrated, ICT devices can transform classroom interactions and actively engage learners' cognition, enhancing their understanding, retention, and processing of content. By stimulating attention, promoting interaction, and supporting diverse learning strategies, ICT holds the potential to enhance cognitive engagement and promote deeper, more meaningful learning experiences.

I feel like my little ones are sometimes bored by the books because if they have to read from my laptop, they become more interested and livelier. **PE**

Even my grade 7s enjoy anything that we do on the laptop, even if they have to share the screen. **PA**

Taking my learners to the resource centre has created this interest in learning and has improved their engagement in all learning activities. **PD**

There are learners in my Grade 2 class who come to school just to play on the laptop, even when I haven't planned to use it. However, I sometimes do use it for them, so they can enjoy learning. **PF**

The deliberate integration of ICT in teaching and learning has a significant influence on learners' cognitive development, enhancing accessibility to education, increasing motivation, creating a stimulating learning environment, and improving learning outcomes. Bindu (2016) concurs that in this digital era, ICT integration positively influences how knowledge and skills are imparted, processed, and internalised by learners. ICTs affect not only how learners are taught but also how they engage with and cognitively process learning content. Gnanamkonda et al. (2019) note that in rural schools, ICT integration can transform the cognitive engagement and behaviour of both learners and teachers. The data indicate that teachers have the potential to lead ICT-driven cognitive transformation in their classrooms. From a rural education perspective, although teachers are expected to possess the trinity of technological, pedagogical, and content knowledge, the constraints and multiple deprivations in rural schools do not absolve them from designing lessons that actively stimulate learners' cognition and foster meaningful, interactive learning experiences.

RESULTS AND DISCUSSION

Teachers need to be intentional in the use and integration of ICTs in teaching and learning, particularly in rural schools where access to digital devices is often limited. Consequently, teachers must approach ICT integration with pedagogical purpose and methodical planning (Hussain, 2020). The data indicate that ICT integration enhances learners' cognitive engagement and understanding of learning content by providing dynamic, interactive, and flexible learning experiences that accommodate diverse learning needs and styles. Bai et al. (2023) highlight that ICT-mediated activities can improve learners' memory retention and information recall, while Abdivalyevna and Farmonova (2024) emphasise that intentional ICT use fosters an environment in which learners develop active and conscious attention. In primary schools, where the central goal is to teach learners how to learn, the strategic integration of ICT can strengthen cognitive processes such as attention, comprehension, and knowledge construction, thereby supporting deeper and more meaningful learning outcomes.

Although rural schools face challenges in accessing ICT tools, the findings reveal that some schools successfully integrate technology into teaching and learning, providing learners with valuable skills and enhancing their cognitive development. Key enablers of ICT integration include resources and infrastructure that support effective technology use in the classroom. Provision of computers, tablets, smartphones, and interactive whiteboards provides both teachers and learners with the tools needed to effectively engage with digital content. Kaumba et al. (2021) argue that, as the digital divide widens, government support is crucial in providing schools with digital equipment and helping teachers acquire ICT knowledge and skills. Technology that is adaptable to the local environment, simple, durable, and easy to maintain ensures continuity of learning. Meanwhile, offline tools pre-loaded with content address the challenges posed by limited internet connectivity. Azano et al. (2020) highlight that ICT integration can support learners' comprehension, promote deeper cognitive engagement, and enhance curriculum delivery. To optimise these benefits, teachers must prioritise learners' cognitive needs, selecting appropriate tools that complement pedagogical objectives rather than treating technology as a substitute for effective teaching. With the right enablers, rural schools can leverage ICT to enhance educational quality, strengthen learners' cognitive abilities, and create opportunities to bridge the digital divide.

Primary school learners often find learning with technology both engaging and enjoyable. Madjid et al. (2023) note that ICT integration can further enhance learners' creativity, self-confidence, and cognitive engagement. By transforming traditional classroom experiences into interactive and dynamic learning environments, technology supports diverse learning styles and provides immediate feedback, all of which foster sustained attention, deeper understanding, and active knowledge construction. ICT enables learners to take ownership of their learning journey, promoting collaboration and fostering higher-order cognitive skills, including problem-solving, logical reasoning, and creative thinking. Taole (2024) asserts that when technology is thoughtfully integrated, it not only facilitates meaningful learner interaction but also strengthens cognitive processes, creating a practical, stimulating, and enjoyable classroom environment. ICT tools, therefore, should complement pedagogical and content knowledge to maximise their impact on learners' cognition and overall learning outcomes.

Rural schools have become adept at leveraging available technologies to enhance learning and strengthen learners' cognitive abilities. Tools such as mobile phones, shared devices, radio and television programs, and offline digital resources provide creative avenues for integrating technology into teaching practices. By utilising these resources, rural schools can make technology a meaningful part of learners' cognitive and learning experiences. The flexibility and resourcefulness of teachers and communities in rural contexts demonstrate that, even with limited infrastructure, the integration of technology can serve as a transformative force in enhancing cognitive development, critical thinking, and problem-solving skills, ultimately improving educational outcomes for all learners.

CONCLUSION AND RECOMMENDATIONS

The integration of Information and Communication Technology (ICT) in primary schools, particularly in rural areas, has the potential to significantly enhance learners' cognitive development. In contexts where resources and infrastructure are limited, ICT provides unique opportunities to bridge educational gaps and promote the development of essential cognitive skills such as problem-solving, reasoning, and knowledge construction. Despite ongoing challenges such as limited infrastructure and restricted access to technology, rural schools that creatively integrate ICT can equip learners with essential cognitive tools for both academic success and future opportunities. Through ICT, learners can engage in meaningful, interactive, and self-directed learning experiences that not only address immediate academic needs but also prepare them for the demands of the 21st century.

To support effective ICT integration, this paper recommends several strategies. Rural schools can leverage available technological resources, including smartphones, personal laptops, and offline digital tools. Radio and television programs covering subjects such as mathematics, sciences, and languages can provide scheduled learning opportunities, ensuring continuous cognitive engagement. Creating sustainable ICT infrastructure is also critical; for instance, solar-powered laptops, tablets, or chargers can mitigate challenges associated with unreliable electricity. Moreover, collaborations between schools and local communities, including businesses, community leaders, and non-profit organizations, can help provide access to vital technological resources. These strategic approaches empower rural schools to strengthen learners' cognitive development, promote equitable access to technology, and cultivate meaningful learning experiences despite limited resources.

REFERENCES

Abdivalyevna, A. N., & Farmonova, E. (2024). Characteristics of the development of cognitive processes in primary school students. *International Journal of Advanced Scientific Research, 4*(3), 35-39. https://doi.org/10.37547/ijasr-04-03-07

Azano, A. P., Brenner, D., Downey, J., Eppley, K., & Schulte, A. K. (2020). *Teaching in rural places: Thriving in classrooms, schools, and communities*. Routledge. https://doi.org/10.4324/9781003106357

Bai, L., Liu, X., & Su, J. (2023). ChatGPT: The cognitive effects on learning and memory. *Brain-X*, *1*(3), e30. https://doi.org/10.1002/brx2.30

Bernacki, M. L., Greene, J. A., & Crompton, H. (2020). Mobile technology, learning, and achievement: Advances in understanding and measuring the role of mobile technology in education. *Contemporary Educational Psychology*, *60*, 101827. https://doi.org/10.1016/j.cedpsych.2019.101827

Bindu, C. N. (2016). Impact of ICT on teaching and learning: A literature review. *International Journal of Management and Commerce Innovations*, *4*(1), 24-31. https://doi.org/10d1wqtxts1xzle7.cloudfront.net

Cassim, V. (2010). *The pedagogical use of ICTs for teaching and learning within grade eight mathematics in South African schools*. Doctoral dissertation, North-West University.

Dakhi, O., Jama, J., & Irfan, D. (2020). Blended learning: a 21st-century learning model at college. *International Journal Of Multi Science*, *1*(8), 50-65.

Denzin, N. K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research*, *6*(2), 80-88. https://doi.org/10.1177/1558689812437186

Elbanna, S., & Armstrong, L. (2024). Exploring the integration of ChatGPT in education: adapting for the future. *Management & Sustainability: An Arab Review*, *3*(1), 16-29. https://doi.org/10.1108/MSAR-03-2023-0016

Enaifoghe, A. O., Balogun, T., & Afolabi, O. S. (2021). The Fourth Industrial Revolution: Integrating ICT in the South African Education System. *Researchers World-International Refereed Social Sciences Journal, 12*(2), 33. http://dx.doi.org/10.18843/rwjasc/v12i2/04

Fernández-Gutiérrez, M., Giménez, G., & Calero, J. (2020). Is the use of ICT in education leading to higher student outcomes? Analysis from the Spanish Autonomous Communities. *Computers & Education*, *157*, 103969. https://doi.org/10.1016/j.compedu.2020.103969

Ghavifekr, S. & Rosdy, W. A.W. (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. *International Journal of Research in Education and Science, 1*(2), 175-191.

Gnanamkonda, V., Koundinya, C., & Krishna, C. G. (2019). ICT in rural school education: impacting on children cognition. *International Journal of Innovative Technology and Exploring Engineering*, *8*(12), 1697-1703. https://doi.org/10.35940/ijitee.L3176.1081219

Güney, K. (2023). Considering the Advantages and Disadvantages of Utilizing Social Media to Enhance Learning and Engagement in K-12 Education. *Research in Social Sciences and Technology, 8*(2), 83-100. https://doi.org/10.46303/ressat.2023.13

Hussain, S. S. (2020). *Intentional, Pedagogically Driven, and Systematic Use of Technology in Teaching Practice*. Doctoral dissertation. University of Southern California.

Joshi, K. R., & Ayer, R. (2024). Teachers' Experiences and Challenges of Integrating ICTs in English Language Classrooms in Rural Schools of Nepal. *Journal of NELTA Gandaki*, *7*(1-2), 28-42. https://doi.org/10.3126/jong.v7i1-2.70183

Karunakaran, S., & Dhanawardana, R. (2023). Integration of ICT in the Teaching-Learning Process: Challenges and Issues Faced by Social Science Teachers. *European Journal of Education and Pedagogy*, *4*(4), 24–30. https://doi.org/10.24018/ejedu.2023.4.4.696

Kaumba, M., Mphahlele, R. S. S., Muleya, G., & Simui, F. (2021). Disablers and enablers in the uptake of information communication technologies in rural primary schools of Mwinilunga District, Zambia. *Journal of Educational Technology and Online Learning*, *4*(1), 1-10. http://dergipark.org.tr/jetol

Kennedy, G. M. (2023). Challenges of ICT integration in teachers' education: A case study of the College of Education, University of Liberia. *International Journal of Social Science and Education Research Studies*, *3*(5), 860-870. https://doi.org/10.55677/ijssers/V03I5Y2023-15

Kibirige, I. (2023). Primary teachers' challenges in implementing ICT in Science, Technology, Engineering, and Mathematics (STEM) in the post-pandemic era in Uganda. *Education sciences*, *13*(4), 382. https://doi.org/10.3390/educsci13040382

Kilag, O. K. T., Segarra, G. B., De Gracia, A. M. L., Del Socorro, A. S., Abendan, C. F. K., Camangyan, G. A., & Mahasol, E. T. (2023). ICT application in teaching and learning. *Science and Education*, *4*(2), 854-865.

Madjid, M., Subroto, D. E., & Rofi'i, A. (2023). Utilization of interactive multimedia in learning English about different kinds of fruits for elementary school children. *Jurnal Mantik*, *7*(1), 263-270. https://doi.org/10.35335/mantik.v7i1.3733

Maja, M. M. (2023). Teachers' Perceptions of Integrating Technology in Rural Primary Schools to Enhance the Teaching of English First Additional Language. *Journal of Curriculum Studies Research, 5*(1), 95-112. https://doi.org/10.46303/jcsr.2023.8

Melieva, D. (2024). Development of independent work skills of primary class students. *World Bulletin of Social Sciences*, *32*, 50-55. https://scholarexpress.net/index.php/wbss/article/view/3929/3345

Meyer, I., Marais, M., Ford, M., & Dlamini, S. (2017). An exploration of the integration challenges inherent in the adoption of ICT in an education system. In *Information and Communication Technologies for Development: 14th IFIP WG 9.4 International Conference on Social Implications of Computers in Developing Countries, ICT4D 2017, Yogyakarta, Indonesia, May 22-24, 2017, Proceedings 14* (pp. 463-474). Springer International Publishing.

Mngomezulu, H., Mkhize, T. F., & Nhlumayo, B. S. (2024). The role of formative feedback in teaching and learning: Grade 10 Physical Sciences teachers' perspectives. *Interdisciplinary Journal of Education Research, 6*, 1-12. https://doi.org/10.38140/ijer-2024.vol6.10

Mpiti, P. T. Makena, B., & Qoyi, M. (2023). Augmented reality for teaching storytelling in a rural foundation phase primary school: Integrating a place-based approach. *Research in Social Sciences and Technology, 8*(3), 105-118. https://doi.org/10.46303/ressat.2023.24

Ngao, A. I., & Sang, G. (2024). How teachers enhance ICT integration practices within professional learning communities: A qualitative study in Tanzania. *Journal of Professional Capital and Community*. https://doi.org/10.1108/JPCC-04-2023-0029

Nhlumayo, B. S. (2024). Rural primary school principals' leadership strategies for ICT integration. Research in Social Sciences and Technology, 9(1), 171-184. https://doi.org/10.46303/ressat.2024.10

Power, J. R., Musgrove, A. T., & Nichols, B. H. (2020). Teachers bridging the digital divide in rural schools with 1:1 computing. *Rural Educator*, *41*(1), 61-76.

Rapanta, C., Botturi, L., Goodyear, P. *et al.* (2021). Balancing Technology, Pedagogy and the New Normal: Post-pandemic Challenges for Higher Education. *Postdigit Sci Educ* 3, 715-742 (2021). https://doi.org/10.1007/s42438-021-00249-1

Saarinen, A. I., Lipsanen, J., Hintsanen, M., Huotilainen, M., & Keltikangas-Järvinen, L. (2021). The Use of Digital Technologies at School and Cognitive Learning Outcomes: A Population-Based Study in Finland. *International Journal of Educational Psychology*, *10*(1), 1-26. http://dx.doi.org/10.17583/ijep.4667

Susilawati, S., & Supriyatno, T. (2023). Problem-Based Learning model in improving critical thinking ability of elementary school students. *Advances in Mobile Learning Educational Research*, *3*(1), 638-647. https://doi.org/10.25082/AMLER.2023.01.013

Taole, M. J. (2024). ICT integration in a multigrade context: Exploring primary school teacher experiences. *Research in Social Sciences and Technology, 9*(1), 232-252. https://doi.org/10.46303/ressat.2024.13

Wang, J., Tigelaar, D. E. H., & Admiraal, W. (2022). From policy to practice: Integrating ICT in Chinese rural schools. *Technology, Pedagogy and Education*, *31*(4), 509–524. https://doi.org/10.1080/1475939X.2022.2056504