Journal of Information Technology Education: Research

An Official Publication of the Informing Science Institute
InformingScience.org

JITEResearch.org

Volume 23, 2024

EXPLORING TEACHERS' USE OF TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE IN TEACHING SUBJECTS IN RURAL AREAS

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ABSTRACT

Aim/Purpose	The current study explored how Technological Pedagogical Knowledge (TPK) influences teachers' delivery of subject content.
Background	The potential value of Fourth Industrial Revolution (4IR) devices is lost if teachers do not integrate them into their instructional practices. Technological Pedagogical Knowledge is one of the components of Technological Pedagogical and Content Knowledge (TPACK), and it can assist teachers in providing learners with the best classroom learning environment while integrating digital devices in the delivery of lessons.
Methodology	The descriptive qualitative multiple case study was conducted at five secondary schools in the rural Bojanala District. Five teachers from five schools voluntarily participated in semi-structured interviews and a document analysis. The thematic analysis of the collected data informed the results of this study.
Contribution	This study contributes to the identification and exploration of the role of TPK in enhancing the integration of 4IR devices into rural secondary schools' instructional practices.
Findings	The study reveals the limited integration of digital devices in teaching due to a lack of infrastructure, a lack of comprehensive understanding of TPK, and the absence of information and communication technologies (ICT) policies at the school level. By analyzing existing policies (or the lack thereof), the study could explain the disconnect between the integration of TPK.

Accepting Editor Aaron M. Glassman | Received: August 6, 2024 | Revised: October 29, 2024 | Accepted: November 8, 2024.
Cite as: Molotsi, A., & van Wyk, M. (2024). Exploring teachers' use of technological pedagogical knowledge in teaching subjects in rural areas. *Journal of Information Technology Education: Research, 23,* Article 30.
https://doi.org/10.28945/5395

Recommendations for Practitioners	Teachers need to be capacitated through follow-up intervention professional development to bridge the gap between understanding TPK and the integration of different digital devices in delivering subject content. Prior to integrating digital devices into teaching and learning practices, teachers must develop or have access to ICT policies and guidelines.
Recommendations for Researchers	The results indicate that even a limited understanding of TPK can motivate teachers to incorporate different strategies brought by 4IR in delivering their lessons, and this needs to be explored further.
Impact on Society	Targeted TPK training and follow-up sessions can further equip teachers with the necessary 4IR transformative skills to design and deliver lessons that effectively prepare learners for the 21st-century real-world work environment. The efforts would assist learners from rural areas schools to benefit from the available technology.
Future Research	The study emphasizes the need for further research to expand the global understanding of strategies for enhancing teachers' TPK, thus contributing to the broader academic discourse on technology integration in education.
Keywords	rural areas, secondary schools, teachers, technological pedagogical knowledge

INTRODUCTION

Implementing the school curriculum involves adopting diverse pedagogical practices in delivering subject content across various disciplines. This includes integrating technology, such as smart boards, laptops, iPads, and smartphones, which transforms how teachers facilitate learning in the classroom. Heilporn et al. (2021) emphasize the importance of utilizing supportive digital tools, especially in asynchronous modes, to enhance learner behavioral and cognitive engagement. To effectively engage learners, teachers need to upgrade their technological pedagogical knowledge and stay abreast of rapidly evolving technological advancements. The ongoing technological transformation, referred to as the "fourth industrial revolution" (4IR) by Schwab (2017), signifies a paradigm shift in content delivery in the 21st century, aiming to enhance lives and address sectorial diversification (Mkude et al., 2023).

While acknowledging that technological pedagogical knowledge is one of the domains of Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006), there is a need to look at this component in an integrated way. The emphasis on TPACK has grown in significance due to teachers facing challenges in adopting new technologies, omitting its incorporation in actual classrooms, and lacking adherence to a specific model in lesson design (Silva et al., 2021). Additionally, teachers, as facilitators of learning, are compelled to transition their teaching methods to align with the Technological Pedagogical Knowledge (TPK) in the TPACK model. This adjustment aims to enhance learners' proficiency in utilizing technology effectively throughout their educational pursuits (Gilakjani et al., 2013).

Despite the potential of digital technologies to provide an interactive learning experience (Agustina et al., 2023), teachers are losing interest due to insufficient devices for all learners and limited electricity and internet access. The study emphasizes the importance of addressing these challenges to harness the potential of Information and Communication Technology (ICT) in South African schools. This argument points to the need for the education sector to provide schools with appropriate technological devices and develop appropriate capacity-building programs to prepare teachers to work effectively with such devices and to enhance teaching and learning. Nevertheless, despite the government's endeavors to incorporate modern technology into secondary education, the utilization of these technologies in teaching and learning remains limited (Mkude et al., 2023).

The study's objective was to explore teachers' TPK to aid the delivery of content using different digital devices in different subjects. It explores how teachers apply their technological and pedagogical knowledge to choose appropriate digital devices or application programs that can assist in changing how subjects are taught. The central question guiding the study was:

How do teachers demonstrate technological pedagogical knowledge in teaching subjects?

The study aimed to broaden discussions on teachers' technological pedagogical knowledge, explaining their views and experiences using various technologies (digital devices) to enhance teaching and learning in diverse subjects.

LITERATURE

The promise of the Fourth Industrial Revolution (4IR) that technology can potentially improve the quality of presenting subject content in education worldwide is evident. For example, Web 3.0 users can search for and read information on the Internet, while tools such as Virtual Reality (VR) and Augmented Reality (AR) hold numerous possibilities for the medical field, business, and education (Schwab, 2023). Faster computers, the Internet of Things (IoT), robotics, and artificial intelligence (AI) open many opportunities for education (Schwab, 2023). However, this only represents a single facet of the overall potential of 4IR technologies. In an interview with the Harvard Business Review, Erik Brynjolfsson and Andrew McAfee mentioned that the abovementioned technological advances managed to magnify the digital divide rather than closing it, creating more inequalities in the job market and industries such as education (Bernstein & Raman, 2015).

Irrespective of the possible digital divide, technology is seen as a driver for educational change and the hope to provide quality education (Haleem et al., 2022). Walking the streets of both developing and developed countries, learners talk on their smartphones, engage in social media, or search the Internet, demonstrating access to mobile devices and ownership of technology devices (Silver et al., 2019). For many learners, this access to technology devices and open access to resources, such as libraries of information through their smartphones, was previously not available (Livingston, 2016). Using devices like smartphones, tablets (Cross et al., 2019), interactive whiteboards (Rustamovna, 2021), and digital platforms (Dey & Bandyopadhyay, 2019) opens many opportunities for teachers and learners. Focusing on South Africa, 95% of the population owns a mobile phone (McCrocklin, 2021), which made us, as researchers, believe that technology is available and can be used as a tool to provide quality education and access to resources (Livingston, 2016).

According to Yurtseven Avci et al. (2020), teachers need to be prepared to integrate technology into their teaching practices to facilitate 21st-century skills development in their students. Technology in education provides students with a dynamic and interactive learning environment, helping to bridge the gap and address the limitations of traditional teaching methods (Balmes, 2022; Gcabashe, 2024). In addition, the integration of technology creates opportunities for teachers to enhance the teaching and learning processes and make the learning experiences for the students more engaging (Tolosa-Casadont, 2022).

Judson (2006) claims that there is a relationship between student-centered beliefs and teacher's eagerness to integrate technology into their classroom. However, the breakdown in the relationship between student-centered teaching and learning and technology integration is evident when looking at the vast amount of research available on TPACK and the teacher's professional development needs to integrate technology in the classroom (Balmes, 2022; Uzorka et al., 2023; Yurtseven Avci et al., 2020).

Recently, a substantial amount of research was published on technology integration, explicitly using the components of the TPACK framework. These studies mainly focused on the application of TPACK (Koh, 2019; Simuja & Silvanus, 2023; Srivastava & Sharma, 2023), pre-service teachers (Joo

et al., 2018; Kapici & Akcay, 2023; Nilsson, 2024; Shambare & Simuja, 2024) and studies focussing on the Global North (Shambare & Simuja, 2024).

For example, Akram et al. (2021) investigated the online teaching competencies of teachers, using all the knowledge of TPACK. Although all the teachers in their study had sufficient knowledge about TPACK, content knowledge was the highest (Schmid et al., 2021; Shambare & Simuja, 2024) and technological knowledge was the lowest (Chisango et al., 2020; Hill & Uribe-Florez, 2020; Schmid et al., 2021; Shambare & Simuja, 2024).

While Alrwaished et al. (2017) found in their comparison of pre-service and in-service teacher's technology integration that pre-service teachers are more confident in integrating technology than in-service teachers, Baran et al. (2019) recommend more research on the development of pre-service teacher's TPACK in teacher education programs. These contrasting ideas indicate the discrepancies between integrating technology in various contexts.

However, there is still a gap between the use of technology and the available infrastructure (Zhang et al., 2022), which hampers the use of technology in rural areas. Specifically in the Global South, teachers experience many challenges when trying to integrate technology. They mentioned low socio-economic status, under-resourced infrastructures, inadequate training opportunities (Chisango et al., 2020; Shambare & Simuja, 2024; Williams et al., n.d.), lack of skills (Chisango et al., 2020; Shilenge & Ramaila, 2020), limited access and support, lack of resources and time, as the main barriers to using technology in the classroom (Chisango et al., 2020; Crompton et al., 2023; Motsoeneng et al., 2021; Shilenge & Ramaila, 2020).

In contrast with teachers in urban areas, teachers in rural areas display lower technology integration due to challenges such as limited access and support (Li, 2024; Shambare & Jita, 2024). Although teachers' technological knowledge is lower in rural areas, teachers are positive and want to learn and grow (Hill & Uribe-Florez, 2020). This willingness to learn is evident when teachers integrate technology, driven mainly by their own initiatives (Shambare & Jita, 2024; Simuja & Silvanus, 2023), especially when they experience the impact of technology integration on their teaching activities (Maja, 2023).

Research on TPACK in rural areas recommends policy interventions to provide teachers access to technology (Li, 2024) and customized professional development specific to rural areas (Li, 2024; Maja, 2023; Schmid et al., 2021; Shambare & Simuja, 2024), since TPACK, and specifically TPK, is crucial for future technology integration (Baier & Kunter, 2020; Celik, 2023). Recently, Celik (2023) advised readers that TPK is crucial to integrating 4IR tools, such as AI, in the classroom. Incorporating the tools needed for 4IR prepares students for future work.

This is also specifically true for the schools in this study, which leads to the question, "How do teachers demonstrate their technology pedagogical knowledge in teaching subjects." In the context of this study, technology is any technology device used in delivering a lesson, such as a data projector, laptop, smartphone, videos, or internet website, and not necessarily the abovementioned 4IR tools. The TPACK framework (Koehler & Mishra, 2009) guided the study. For this paper, we will focus on the TPK part of the framework. This study contributes to the body of knowledge by focusing on the TPK of in-service teachers in the Global South.

THEORETICAL FRAMEWORK

As mentioned, the Technological Pedagogical Content Knowledge (TPACK) framework developed by Koehler and Mishra (2009) guided this study (Figure 1) with a focus on the Technological Pedagogical Knowledge (TPK). With the increased interest in using technology and the possibilities of dealing with complex problems in the classroom, teachers feel pressured to integrate technology as part of their teaching and learning activities (Kurt, 2019). Although teachers and schools experience physical obstacles such as electricity, data, and the number of devices in using technology, many

teachers also lack the knowledge of how to teach using the technology in their specific subject field (Chisango et al., 2020; Schleicher, 2020). Therefore, the integration of the three knowledge of TPACK, provides a guiding mechanism to assist teachers to take their knowledge of how to teach (Pedagogical Knowledge) their specific subjects (Content Knowledge) and select appropriate technology (Technological Knowledge) to engage learners, let them explore new fields, support their learning, and improve the learning experience (Koehler & Mishra, 2009; Kurt, 2019). It is important to notice that in any classroom, the focus is first on what to teach (subject content) and how to teach (pedagogy and teaching strategies) so that learners can achieve the learning outcomes and then use technology to achieve them (Kurt, 2019).

Content Knowledge (CK) refers to the subject knowledge of teachers, in other words, what they teach in class (Koehler et al., 2013). CK will differ according to the subject field and the grade level of the learners (Kurt, 2019), and therefore, teachers need to understand the "deeper knowledge fundamentals" of the subject fields they are teaching (Koehler et al., 2013, p.14). Subsequently, the subject content can be prescribed by a government body like the Department of Education, as described by Absari et al. (2020), or determined by what teachers studied as part of their teacher qualification. A previous study found that pre-service teachers are confident in their subject knowledge and, therefore, would be able to use their content knowledge effectively in a classroom (Santos & Castro, 2021). Also, Heggart (2016) stresses the importance of subject knowledge in developing an understanding of what is required from teachers in the classroom. However, seeing content knowledge in isolation will have a limiting influence on the learning of learners and needs to be seen in combination with a variety of other skills, such as learner-centeredness and pedagogical knowledge (Heggart, 2016).

Koehler and Mishra (2009) explain Pedagogical Knowledge (PK) as the knowledge of the process of how learners learn, how the teacher plans for and teaches, and how the learning outcomes are achieved while managing the classroom. The importance of PK is stressed by Absari et al. (2020), who found that the level of PK influences the learning process, which directly affects the other elements of TPACK, such as the use of technology.

Technological Knowledge (TK) is not as easy to describe as CK and PK (Koehler & Mishra, 2009). Since technology is changing as we speak, defining and pinpointing it is difficult. However, how one thinks about the technology one uses might be the same for various technologies (Koehler et al., 2013). Even though technology is part of teachers' and learners' everyday lives, technology is constantly changing, resulting in a lifetime of interaction with technology (Koehler et al., 2013). For example, new devices, applications, or updates are released daily. So, the challenge is to adapt how one uses technology as well as which technology is the most suitable to achieve the learning outcomes (Koehler et al., 2013). Interestingly, Absari et al. (2020) found that TK influences teachers' ability to integrate CK and PK, emphasizing the importance of training before using technology in the classroom as well.

Technological Pedagogical Knowledge (TPK) refers to the interaction of technology and pedagogy (Koehler et al., 2013). However, a study by Makawawa et al. (2021) shows that the abilities of TK and PK still need to be improved. Absari et al. (2020) found that PK influences TPACK, as low PK impacts other areas of knowledge. However, the same is not true for TK, as TK alone does not affect TPACK. The findings of Absari et al. (2020) indicate that knowledge of technology and pedagogy improves teachers' ability to combine technology knowledge, pedagogy knowledge, and content knowledge in the classroom. Therefore, TPK has a positive influence on TPACK, demonstrating the importance of training teachers in both areas to enhance their teaching effectiveness.

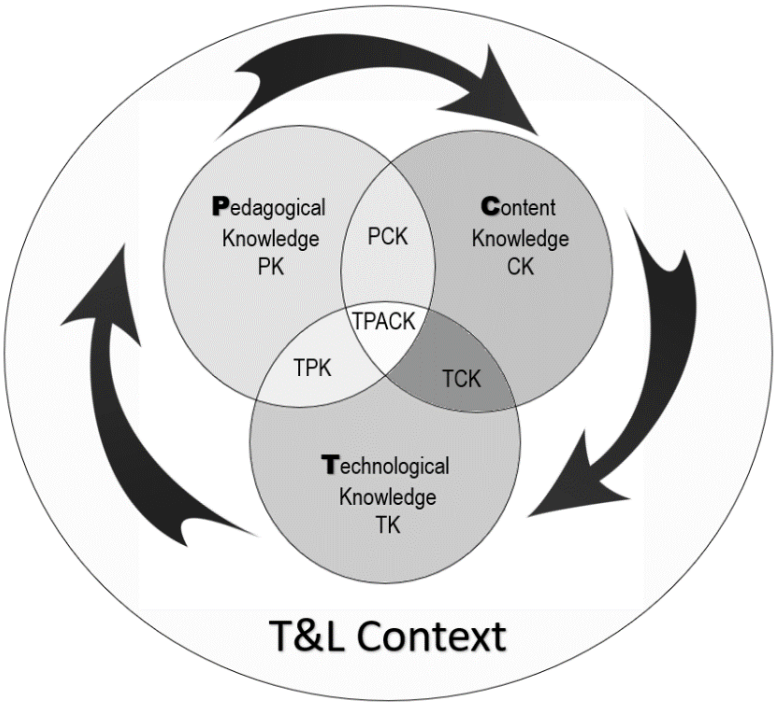

Figure 1. TPACK framework adapted from the original image by Koehler and Mishra (2009) and reproduced by permission of the publisher ©2012 by tpack.org

In the context of this study, all the teachers have teacher's qualifications and are teaching at the government public schools teaching a variety of subjects at the Grade 9 level, assuming that they are teaching the content as provided by the Department of Basic Education (CK). As part of their formal training as teachers, teachers are all trained in teaching processes such as lesson plans, learning theories, and teaching strategies (PK). However, using technology (TK) might have been an elective subject during their training, depending on where and when they obtained their qualifications. Since it was found that PK and TPK components had a significant effect on TPACK (Makawawa et al., 2021), there is a need for this study and the focus on TPK. TPK describes teachers' understanding of how particular technologies can transform the delivery of content in a way that is appropriate to the subject and the lesson at hand (Mishra & Koehler, 2006; Yigit, 2014). Ideally, technology-enhanced lessons are a major strategy that improves teachers' delivery of content (Yigit, 2014). Although TPACK components are inseparable (Mishra & Koehler, 2006) for effective technology integration in the classroom, the researchers in this study focused on TPACK to explore the knowledge of teachers in terms of delivering content using digital devices. Additionally, in this study, TPACK guided the researchers in terms of the research questions for the semi-structured interview. The questions focus on how teachers' pedagogical practices were enhanced by the integration of ICT in delivering content. In essence, teachers are expected to stay current with new technological pedagogical strategies for the benefit of their learners.

RESEARCH METHODOLOGY

Using an interpretive paradigm, a qualitative descriptive research design was employed in this study (Creswell, 2014; Yin, 2018). To explore how teachers integrate technology when teaching (TPK) their Grade subjects, a multiple case study (Yin, 2018) was conducted at five secondary schools in the rural area of Bojanala District, the Dinaledi cluster. The five secondary schools represented the multiple cases as natural, real-life settings where data was collected. This study used convenience and

purposeful sampling to choose available participants (Creswell, 2014) with knowledge of integrating ICT in teaching and learning (Omona, 2013). Within five secondary schools, five teachers voluntarily participated in the study and demonstrated knowledge about using technology while delivering content (TPK). The researchers purposefully selected participants based on their knowledge of integrating ICTs in teaching and learning (Omona, 2013). Semi-structured interviews and a document analysis instrument were used to collect rich qualitative data. The interview questions were designed based on teachers' technological pedagogical knowledge with the research question in mind. The semi-structured interviews were recorded to avoid missing essential information about the shared experiences of the participants regarding the integration of ICT in lesson presentations. The duration of the interviews took between 30 minutes and one hour, depending on the deliberations and prompt when the need arose. The semi-structured interviews were then transcribed and inductive analyzed systematically using codes and categories according to the themes that emerged as suggested by Seidel (1998) (Figure 2).

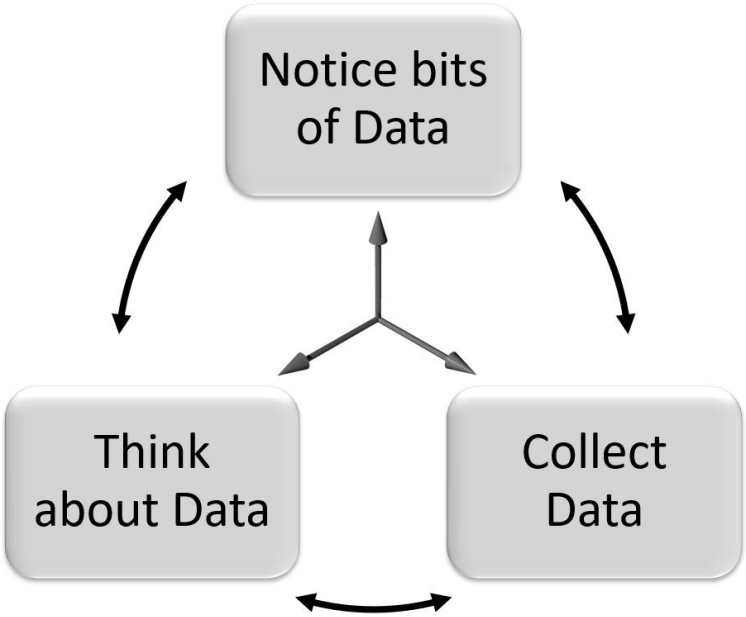

Figure 2. Data analysis process as adapted from Seidel (1998)

Regarding the document analysis, the researchers requested the national ICT policy, the school ICT policy, and the Professional Development Framework from the participants. These documents serve as guiding documents in a school setting to facilitate the integration of ICT in teaching and learning. The data analysis was done based on the set criteria.

Ethical clearance was upheld through the completion of ethics application forms and submitted to the College of Education Ethics Committee of the University (2020/09/09/90173651/05/AM). Upon approval, the fieldwork was done. Ethics was also adhered to by the following principles: anonymity, informed consent, and confidentiality. The researchers explicitly explained to the participants their roles in the study so that they made an informed decision by participating in the study. Pseudocodes P1 to P5 were used to write about the shared experiences of the participants pertaining to the presentation of the lessons using digital devices.

FINDINGS AND RESULTS

BACKGROUND OF THE PARTICIPANTS

Although this study did not focus on the different roles female or male teachers played or even their respective access to devices and the delivery of their content using digital devices, the results show only males participating in the study. This single-gender participation was not anticipated. The results depict (Table 1) that most of the participants' ages ranged between 20 and 30 years, whereas only one participant was between 31 and 40.

Table 1. Participants background information

Participants	Gender	Age	Grades teaching
P1	Male	20-30	8-12
P2	Male	20-30	8-12
P3	Male	20-30	8-10
P4	Male	20-30	8 and 10
P5	Male	31-40	8-12

The age illustration shows that most of the participants in this study belong to the digital natives category, the current generation born between 1980 and 2000. According to Goru Dogan (2014) and Prensky (2001), they possess technological skills because they grew up in an environment surrounded by technology. In the context of this study, only one participant could be classified as a digital immigrant (McLean, 2024).

During the interviews, the participating teachers revealed that they offer subjects from grades 8 to 12, indicating teaching experience in all grade levels. However, this study focused on grade 9 teachers and their presentation of subject content in their grade 9 classes using technology.

FINDINGS

The following section explains the qualitative inductive data analysis, which involved five participants who volunteered to share their real-life experiences regarding the presentation of subject content using different digital devices. Employing the Seidel (1998) model (Figure 2), we noticed bits and pieces of the collected data when we visited the schools (Notice), recorded our observations, interviewed the teachers (Collect), and read the transcripts of the interviews (Think), which led to the formation of codes and emerging themes. After the formation of themes, we adapted Attride-Stirling's (2001) thematic network structure to display the analyzed data appealingly and understandably (Figure 3). From the gathered data, one global theme, TPK, and six organizing themes, namely, digital device usage, frequency of use, the available infrastructure, overcoming technical problems, improvement of pedagogical practices in schools, and background training, emerged from the findings. The six organizing themes that emerged from one global theme, namely Technological Pedagogical Knowledge, are discussed next.

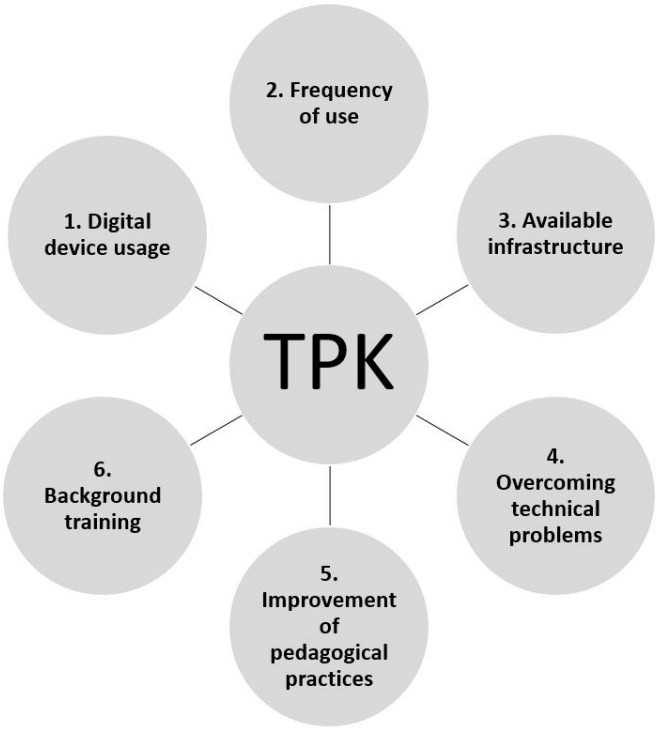

Figure 3. Technological pedagogical knowledge global theme with six organizing themes

The responses about the digital devices' use of organizing themes evidenced that most of the participants do not deliver subject content through digital devices; hence, there is limited usage of the available digital devices. Two of the participants said:

> Not always; if you are talking about only grade 9, I thought maybe you are referring to all the grades. (P1)
>
> I often, I use like maybe twice or once in a week. (P2)

When the participants were asked about how often they **use digital devices (frequency)** in presenting content, the results revealed limited integration of digital devices in teaching and learning for most of them. As noted in the participants' background information, most of them teach grades 8 to 12; hence, particular attention was given to grade 12 classes as the yardstick of a school's performance. Thus, the results revealed that the grade 9s suffered in terms of attention and technology integration.

> According to P3, "So far, we don't integrate that much. Grade 9 is overlooked because priority is Grades 10-12."

Concerning the **available infrastructure** organizing theme, the participants voiced varied real-life experiences with available infrastructure. One commonality was that the district had provided all the grade 12 learners with tablets with readily available syllabi and their teachers with laptops. The following is verbatim evidence of the results. P3 and P5 elaborate:

> All teachers have laptops; the Grade 12 learners have been given tablets. (P3)
>
> But I think teachers have their laptops. Grade 12s were given tablets early this year. So only grade 12s were given. Other than that, they don't have. It is for teachers, almost every

> teacher has a laptop. We do have projectors or sometimes, when educators can also use laptops. (P5)

The above reiterates prioritizing the grade 12 learners over the grade 9 learners.

More evidence about available ICT infrastructure was raised, for example:

> Our school has the interactive whiteboards, it also has the projector, and then laptops, yes, and that is what we have in our school, the laptops it is only for educators who teach grade 12. (P2)

Teachers' technological skills enable them to **overcome technical problems** or troubleshooting problems when integrating ICT into teaching and learning. The findings point to participants having varied views. The following excerpt has references:

> So, for example, maybe I want to present a lesson, and then, it is whereby maybe I feel like I could just use some videos and then demonstrate to learners. I had to download them, not at school, since I am not staying in the same village where the school is at. (P1)

Improved pedagogical practices could be triggered using the relevant ICT. Participants believe that training on how to select and integrate the relevant ICT is the best yardstick (P3), while P5 viewed the need to start using technology at an early stage as important to be able to improve pedagogical practices. P4 saw the need to be assessed by learners' observation as crucial and that the provided feedback could encourage improving pedagogical practices. However, P2 was discouraged from improving pedagogical practices because of the limited electricity supply. More obstacles are also evident in the following:

> Our schools have a challenge of not getting enough classrooms. If you are planning to deliver with a projector, you are allowed to use the projector in a spare space like a storeroom. (P3)

> There is poor support in our school because even now, we cannot access the Internet and the WiFi, and that is where we can get more information, but we don't have such things. (P2)

Delivering background training for ICT lessons for teachers is crucial to ensure that teachers are well-equipped with technological pedagogical knowledge skills and ready to execute their roles in teaching and learning. Not all the participants received training. While P5 received ICT training when he furthered his university studies, P2 depended on self-training and admitted that they received no training. The following excerpts bear references.

> Yes, we are using experience from the university. No, we don't have any training from the circuit or the school. (P5)

> Eish, I did not receive any training. I just learned how to use these by myself. (P2)

Regarding the document analysis, the study wanted to confirm the availability of guiding documents that are provided to assist in the integration of ICT in secondary schools. When fieldwork was done, the researchers requested the National ICT policy, schools' ICT policies, and the Professional Development Framework for digital learning documents. The intention was to find out if the policies indicated were available and that they served the purpose of guiding and assisting teachers in accumulating more knowledge about the use of ICTs and the ability to implement what is stipulated in the documents.

As illustrated in Table 2, only one out of five secondary schools the researchers visited has its own ICT policy. Schools are expected to create their own ICT policy, which is an essential guide that assists schools in ensuring the correct route to pursue in terms of safety, legality, and effective integration of ICT in education (Al Mofarreh, 2016). In addition, none of the schools had the National ICT Policy or the Professional Development Framework for Digital Learning. All the documents serve the same purpose as the schools' ICT policies.

Table 2. Document analysis of ICT Policies and framework

	School A	School B	School C	School D	School E
School ICT Policy	Yes	No	No	No	No
National ICT Policy	No	No	No	No	No
Professional Development Framework for Digital Learning	No	No	No	No	No

DISCUSSION OF RESULTS

In this study, technology integration is considered a form of assisting teachers in connecting with peers globally to augment their virtual collaborations, enabling them to deliver content using diverse ICTs that enforce the sharing of their ICT expertise. From the gathered data, one global theme, TPK, and six organizing themes, namely, digital device use, frequency of use, the available infrastructure, overcoming technical problems, improvement of pedagogical practices in schools, and background training, emerged from the findings. This study confirms the work of Chigona et al. (2014), who found that educators' motivation to use **digital devices** for subject content delivery could be impacted by the satisfaction derived from using the ICTs; contrarily, in this study, digital devices were not used. Arion et al. (2024), in their study evaluating the digital penetration in rural areas, found that factors influencing the use of digital devices include income, age, and proximity to urban centers. Teachers in rural areas may show a dire commitment to letting their learners benefit from using laptops and data projectors since there is no need for an internet connection; hence, the projected information stimulates learners' perception of learning. It shows commitment on the part of teachers, and the use of the available digital devices is a motivation to join other teachers who use technology for teaching globally (Hill & Uribe-Florez, 2020). In their study, Mwapwele et al. (2019) also revealed that despite the financial, technical, and digital skills challenges teachers face, they were optimistic about using digital devices (Maja, 2023), indicating readiness to join the ICT usage clientele.

Lin et al.'s (2015) study on factors influencing teachers to use technology revealed that too little has been known about key factors that successfully assisted teachers in the use of digital devices in teaching and learning. Additionally, their study revealed that teachers' readiness to use technology was lacking. Technological knowledge in terms of pedagogical practices is key to transforming the delivery of content. Furthermore, Nikolopoulou (2020), in conducting empirical research, showed that when teachers' perception of the use of digital devices was limited, it was not easy for them to sort out the challenges that surfaced.

In this study, the **frequency of digital device usage** for grade 9 learners is not supported because the same teachers also teach Grade 12 subjects. These teachers receive support for Grade 12 in the form of laptops and tablets for Grade 12 learners. The available technology is not at all learners' disposal since Grade 12 or exit level grades are prioritized over lower grades.

Chigona et al. (2014) stress that, with ICT integration, teachers' expectations need to be provided with **ICT infrastructure**, as in the case of this study. Adam and Tatnall (2017) share the same sentiments by asserting that inadequate ICT infrastructure plays a crucial role as teachers are denied the ability to develop and deliver content using ICTs (O'Doherty et al., 2018). In addition, Padayachee's (2017) study of surveying the integration of ICT in South African schools' results yielded the uncertainty of teachers concerning ICT integration as they were burdened by poor infrastructure.

Considering the first three organizing themes, it is evident that most participants do not integrate or use digital devices due to limited ICT infrastructure, which hinders the accumulation of TPK.

The limited **technical support** that surfaced during the current study could not go unnoticed. Similarly, the findings from the empirical research revealed that insufficient technical support, lack of

technology-equipped laboratories, and lack of electricity in schools discourage teachers from integrating ICTs in delivering their lessons (Chisango et al., 2020; Ghavifekr et al., 2016; Mirzajani et al., 2016). Another study conducted by Villalba et al. (2017) on the perception of Physical Science teachers regarding barriers to integrating ICT in teaching and learning found technical problems as one of the major concerns of content delivery. Barrett and Slavova (2017) argue that overcoming technical problems in content delivery can be addressed by regulating the ICT environment, regularly checking networks and digital devices, and updating business ICT models (Li, 2024).

The participants in this study developed strategies to deliver content using ICTs, which augmented their **pedagogical practices** (the use of videos). This study confirms the work of Pavez et al. (2024) and Shambare and Simuja (2024) that teachers in rural areas often develop strategies to enhance learners learning despite the challenges of digital exclusion. Notably, teachers' use of videos is advancing at an alarming rate as they no longer have to try to make learners understand the content. Instead, the strategy of how content is delivered makes learners need to learn more. The use of video, for example, YouTube videos, as an educational source for instruction was seen to be a digital tool that transformed the pedagogical practices (Fyfield, 2022) and attitude (Alwehaibi, 2015) of teachers. However, the poor infrastructure at schools magnified the fact that participants need to download videos at home to be used in school.

Like the work of Li (2024) and Shambare and Simuja (2024), participants emphasize the importance of training, using technology from an early age, and learning from learner feedback as crucial to improve Technological pedagogical practices. Be that it may, **background ICT training** also offers teachers with professional development that enhances their ICT skills. Despite teachers' professional development, a well-equipped computer lab can promote the instructional process as teachers can use the various digital devices available (Mukuna, 2013). Nyaga (2018) and Maja (2023) support the idea that background ICT training for in-service teachers assists them in integrating ICT into teaching and learning. From this study, the lack of background training was evident in their lack of ICT integration.

The participating schools are expected to create their own ICT **policies** derived from the National policy or the Professional Development Framework to ensure coherence in all the documents. Considering the lack of "paper" guidance, the poor state of technology pedagogical knowledge integration in the classroom is not surprising. In the study conducted by Vo (2019), the findings revealed that the absence of ICT policies at both national and institutional levels was a hindrance to a lack of professional development and support. Since these ICT policies and professional development frameworks are usually the first step before implementing an ICT strategy, the lack of these documents has influenced the use of technology in schools (Li, 2024). Barrett and Slavova (2017) argue that ICT policies require a holistic approach that includes infrastructure, digital devices, and troubleshooting services as a socio-technical system. They further contend that effective policies should enforce ICT accessibility and affordability to support low-cost digital devices. Poudel (2010) views the frequent revision of ICT policies as a method to extend ICT benefits in rural areas.

That being the case, Vanderlinde et al. (2012) identified three types of ICT plans in their study. The first ICT policy is regarded as a vision blueprint for ICT integration in schools. The second is a technical inventory that incorporates ICT into teaching and learning activities, addressing issues such as educational software and troubleshooting challenges. Third, an ICT policy should be comprehensive, touching on several aspects that inform effective ICT integration, such as learners' safety and well-being, legal obligations, and guidance regarding its integration in teaching and learning.

None of the five schools has a National Policy (The White Paper on e-Education 2004). Blignaut et al. (2010) conducted a study comparing the South African ICT policy with the Chilean-based ICT policy. The findings revealed three key points: first, the policies reflected their respective national backgrounds and initiatives; second, they described different approaches to ICT integration; and third, they highlighted the accessibility of ICT resources, the support provided to teachers, and the

principals' pedagogical visions, as well as how ICTs were used in teaching and learning. The comparison between the policies highlights commonalities and emphasizes the importance of national policies, as well as both technological (access to devices, use of devices) and pedagogical practices when integrating ICTs.

Again, none of the five schools have a Professional Development Framework for Digital Learning. The main aim of this framework is to "Define professional development for digital learning in an education system that seeks to improve access, quality, equity, redress, and efficiency" (Department of Basic Education, Republic of South Africa, 2018, p. 9). All South African schools are expected to have a framework to ensure a productive digital teaching and learning environment. Olika et al. (2019) conducted a study focusing on the teachers' professional development (TPD) with more emphasis on the integration of digital technologies into the curriculum. The findings yielded inadequate digital technology teacher professional development programs (DTTPDPs) provided to teachers.

CONCLUSION

This study set forth to explore how teachers demonstrate technological pedagogical knowledge in teaching subjects. Through the analysis of the delivery of content using different digital devices, six organizing themes emerged: digital device usage, frequency of use, available infrastructure, overcoming technical problems, improvement of pedagogical practices in schools, and background training.

The findings revealed the participants' limited integration and use of digital devices. Although other studies acclaim the use of digital devices to support disadvantaged learners, support remedial learning, and cater to various learning styles (Adam & Tatnall, 2017; Benmarrakchi et al., 2017), the findings of this study revealed limited integration of digital devices with sporadic use in the grade 12 classes. Although digital infrastructure is available (O'Doherty et al., 2018), it is prioritized for use by grade 12 learners and teachers. Since ICT integration is supposed to empower teachers with digital skills, the lack of support, electricity, appropriate venues, and sufficient training discourages teachers from improving their pedagogical practices (Mishra & Koehler, 2006).

From the organizing themes, it is evident that most participants do not deliver subject content through digital devices, and the available digital devices are limited. Since limited ICT infrastructure hampers the use of technology, some teachers were resilient and sought methods to work around the lack of Internet and training. Only limited pedagogical improvement was visible.

This study is particularly valuable for teachers in similar rural areas and has the potential to influence a shift in teachers' perspectives on incorporating modern technology. Teachers may need to reconsider their attitudes toward using these tools, fostering a more positive mindset in the teaching process. The findings also hold significance for researchers exploring the integration of technology in teaching and learning across different subjects. The study recommends that professional development can be used to empower teachers to use digital devices and strategies to integrate the use of 4IR tools in their lessons in such a way that learners will understand the subject content.

The study highlights the importance of ICT Policy and guiding documents and recommends that each school have an ICT policy and access to guiding documents from the Department of Education before teachers attempt the integration of digital devices. The next step for this study will be the exploration of different technological pedagogical strategies (TPS) that can be used to deliver subjects' content. Information gathered would be collated and shared to assist teachers in rural areas curbing TPK knowledge. This could contribute to the broader discourse of technology integration in the rural regions of the Global South.

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