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Exploring secondary school teachers' use of the Technological Pedagogical and Content Knowledge (TPACK) model in delivering subject content after the COVID-19 pandemic disruption threat

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ABSTRACT

The integration of digital devices in education has been widely practised throughout the world. The vast availability of digital devices enables teachers to prepare and deliver subject content in different ways. Despite the availability of various digital devices in the Fourth Industrial Revolution, some teachers still experience "technostress" in terms of the delivery of subject content. The COVID-19 pandemic severely disrupted the delivery of subject content causing a tremendous change within educational settings globally. To explore secondary school teachers' use of the Technological Pedagogical and Content Knowledge model in delivering content, this study used a qualitative multiple case study research design. The empirical data were collected from seven secondary school teachers and were thematically analysed. The findings from non-participant observation and semi-structured interviews assisted in revealing teachers' use of the Technological Pedagogical and Content Knowledge model in delivering subject content. The findings point to a lack of digital devices within the selected secondary schools as well as teachers' limited knowledge of online delivery of content. It is recommended that schools be provided with ICT infrastructure and be taken on board with training on how to use them.

Keywords: *COVID-19; digital devices; online learning; technological pedagogical and content knowledge; secondary school teachers; subject content delivery*

INTRODUCTION

Online delivery of subject content has gained more attention since the start of the COVID-19 pandemic as teachers had to choose the constructivist approach to teaching and learning over the traditional approach (ElSaheli-Elhage 2021). Despite efforts from the teaching fraternity to enable teachers to continue with the delivery of their subject content online after the COVID-19 pandemic, some teachers are still reluctant to adapt to the new means of delivering subject content using digital devices (Kim et al. 2021). In essence, teachers should be encouraged to integrate digital devices into the delivery of content (Kim et al. 2021). However, some teachers may doubt their ability to integrate digital devices delivering content, despite the COVID-19 pandemic crisis having forced them to shift to online delivery of subject content. Additionally, the rapid growth of online delivery of subject content after the COVID-19 pandemic was seen to be inevitable (Lee & Han 2021), as the delivery of content online gradually became the main vehicle for disseminating learning. Online delivery of subject content provides an opportunity for interactive learning among learners and makes learning interesting (Alkahtani 2017). To accept online teaching and learning as a pathway for education to be fulfilled, the delivery of content should be transformed to have the potential to improve the quality of education (Dewa 2022).

The adoption of online learning during the pandemic has created a clear route of transformative educational teaching and learning for teachers to adapt to online learning (Lockee 2021). Nevertheless, some technophobic teachers cannot refrain from the traditional subject content delivery. Moreover, education continuity can be challenging after the COVID-19 pandemic, as teachers may view online delivery of subject content problematic rather than a necessity (Kim et al. 2021).

Furthermore, teachers as educational agents had no choice but to shift their pedagogical approaches towards the TPACK model, which, will better prepare learners for highly skilful and competent use of hardware and software throughout their learning endeavours (Gunu, Nantomah & Inusah 2022). Ideally, TPACK describes the form of knowledge teachers need to effectively deliver subject content in an integrated technology teaching and learning environment (Inpeng & Nomnian 2020). The shift from the old traditional teaching method using pen, paper and chalkboard (Ally 2022) to embracing online delivery of subject content using the TPACK model might be an enormous instructional mindset shift for some teachers. The online delivery of subject content requires teachers to be technologically skilled and competent. The use of the TPACK model enforces creativity and effectiveness in developing new styles of pedagogical practices that are responsive to a 21st Century teaching and learning environment.

Online delivery of subject content transforms pedagogical practices; however, there is a need for support to fully embark on this progressive journey of online delivery of content (Gunu et al. 2022). The goal of the use of digital technologies in the classroom is to enhance the achievement of learning outcomes, even though many public schools in South Africa do not integrate technology into their curricula (Dewa 2022). Based on the above deliberations, most studies have been conducted on online delivery of content and limited studies have been done on the use of the TPACK model in the delivery of content after the COVID-19 pandemic. This study sought to explore secondary school teachers' usage of the TPACK model in delivering subject content.

LITERATURE REVIEW

The TPACK model

Mishra & Koehler developed the TPACK model to explain or guide effective technological integration into teaching and learning (Mishra & Koehler 2006). The model focuses on technological knowledge, technological pedagogical knowledge and technological content knowledge (Swallow & Olofson 2017). The three types of knowledge explain how the choice of technology is made, what is taught and how a teacher imparts subject content to learners (Koehler, Mishra & Cain 2013; Swallow & Olofson 2017). The three types of knowledge are intertwined and form a solid grounded technology-integrated teaching and learning environment.

The TPACK model provides teachers with unique knowledge that enables them to design technology-integrated instruction for effective delivery of content (Mishra & Koehler 2006). In line with this, teachers should be able to navigate the selected technological devices, use a strategy that is technologically inclined and subject expertise to make online delivery of subject content meaningful and interesting.

Figure 1 below provides a graphic representation of the TPACK model.

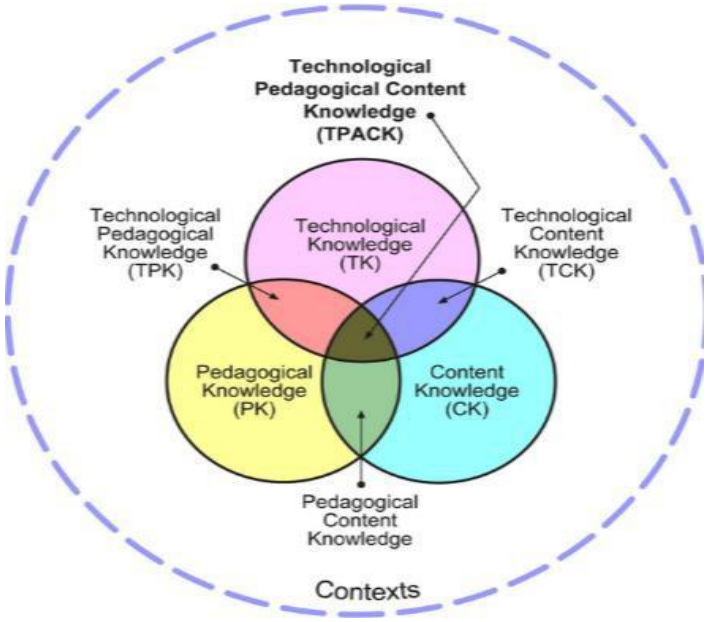

image ©2012 by tpack.org

Figure 1: The TPACK model

Studies have been conducted on the use of the TPACK model in teaching and learning environments, for example that of Inpeng & Nomnian (2020). Their study focused on how the three components of TPACK (technological knowledge, technological pedagogical knowledge, and technological content knowledge) allow for efficient and effective delivery of lessons. The key findings revealed average use of Teaching English as a Foreign Language (TEFL) by Thai pre-service EFL teachers as a result of their limited technological pedagogical online skills.

Koehler et al. (2013) in their study attested that the three components of the TPACK model should be used in conjunction to enhance the learning experience. Taopan, Drajati & Sumardi (2020) shared a similar perspective, as the relationship between the three components is purposefully blended.

However, the adoption of the TPACK model may differ from one teaching and learning environment to another as a result of technology infrastructure, different pedagogical practices and teachers' subject expertise. For this reason, the online delivery of subjects requires acknowledgment of the uniqueness of every school's context, including the professional development school dynamic and available resources (Swallow & Olofson 2017; Taopan et al. 2020).

The types of knowledge in the TPACK model consist of the following:

Technological knowledge which refers to teachers' knowledge of different digital devices and the ability to operate such technologies for instructional purposes (Inpeng & Nomnian 2020; Swallow & Olofson 2017; Taopan et al. 2020). ***Technological pedagogical knowledge*** involves teachers' ability to integrate technological tools alongside pedagogies in ways that are appropriate to the development and subject content delivery at hand (Swallow & Olofson 2017; Taopan et al. 2020). ***Technological content knowledge*** concerns teachers' understanding of how technology and content can influence the learning of subject content and learner practice taught through appropriate technology usage (Inpeng & Nomnian 2020; Swallow & Olofson 2017; Taopan et al. 2020). Teachers' subject expertise may assist in the choice of an appropriate technology that

enhances the achievement of learning outcomes. The purpose of this study was to explore secondary school teachers' use of the TPACK model to deliver subject content.

The use of digital devices in teaching and learning after COVID-19

The integration of technology during the COVID-19 pandemic was no longer an option, but mandatory in order to deliver subject content to sustain normality during the academic calendar (Li & Lalani 2020). Teachers started to believe that technology integration into classroom activities benefits the teaching and learning process effectively helping them to overcome the complexity of the tuition process (Taopan et al. 2020).

Many studies have been conducted on online teaching and learning after the COVID-19 pandemic. Mhlanga & Moloi (2020) assessed the influence of the COVID-19 pandemic on motivating digital transformation in the education sector in South Africa. Their findings revealed that in South Africa, various digital devices were distributed from primary education to higher education institutions, and teaching and learning strategies were switched to remote online learning. The provisioning of digital devices in South Africa was inevitable, as online teaching and learning had to continue as a path to the realisation of education. Mhlanga & Moloi (2020) argued that digital transformation in education remains a critical issue that requires a high level of governmental intervention. According to them, infrastructure and the technical knowledge of teachers in subject content delivery can increase education excellence.

Korkmaz & Toraman (2020) analysed teachers' online teaching transformation after the COVID-19 pandemic. Their findings revealed that most of the teachers in their study experienced challenges in online learning practices. These challenges included among others, connectivity, interaction within the platforms, online assessment and delivery of content. Susilawati & Supriyatno (2020) investigated the online learning process in the middle of the pandemic. The results pointed to an increase in online learning during the pandemic. Tadesse & Muluye (2020) explored the impact of the COVID-19 pandemic on the education system in developing countries. Their findings showed that the developing countries designed strategies for online learning which relates to free Internet access, ease of availability of educational resources and the broadcasting of teaching.

Online delivery involves the use of the TPACK model even though teachers may not be aware of the model or be knowledgeable about it, as it is involved in all technology-integrated subject content delivery.

METHODOLOGY

Research Design

This study adopted a qualitative multiple case research design. The data collection was conducted in the natural settings of four secondary schools in the Dinaledi cluster, Bojanala district, Northwest province. All four schools are situated in rural areas. The grades in the schools are from Grade 8 to Grade 12. The TPACK model was explored within all grade 9s and in any subject across the curriculum, as teaching was done in all grades across the curriculum.

Population and Sampling

The target population was 37 Grade 9 teachers in secondary schools. The Grade 9 teachers also offered subjects in Grade 8 to Grade 12. Before the participants volunteered to take part in this study, clarity was provided in respect of their role in the study to enable them to make an informed decision about participating in this study. Purposeful convenience sampling was used, as all teachers were expected to integrate technology devices into their classroom practices. In the

context of this study, the seven participants who volunteered were expected to display the three types of knowledge in the TPACK model in their online delivery of subject content. To respect and ensure their integrity and privacy, the codes T20, T21, T22, T28, T30, T31 and T32 are used. Table 1 illustrates the participants' biographical details.

Table 1: *Biographical details of the participants*

Participants	Gender	Age	Teaching grades
T20	M	30–40	8, 10, 11, 12
T21	M	20–30	8–12
T22	F	20–30	8–10
T28	F	20–30	8–12
T30	F	41–50	8–12
T31	M	41–50	8–12
T32	M	30–40	8–12

Four men and three women participated in the study. The participation was voluntary and delivered subject content using different digital devices. The age range on the above table shows the possibility of a mixture of digital natives and digital immigrants. Three participants were born in the technological era that is between the years 1980s and 2000s.The remaining four were born before then. A digital native is a person who was born during the information age and can comfortably navigate digital devices without manual assistance (Prensky 2012). A digital immigrant is a person who was born before the information age (Kesharwani 2020). The adoption of technology differs according to the participants' age ranges. Digital natives do not strive to get to know or use technology devices, as they grow up using them, while digital immigrants strive to be counted among technologically savvy people (Kurniawati, Maolida & Anjaniputra 2018) because they were born before 1980 and are less proficient users of technology (Kesharwani 2020).

Data collection methods

An in-depth semi-structured interview was administered to seven participants in an environment free from disturbances. An interview guide questionnaire was prepared and validated to draw expected information from the participants. The process of data collection was audio recorded within an hour and focused on probing between the participants and the researcher. The recorded data was transcribed and analysed as explained below. Another data collection strategy was non-participant observation. A researcher sat at the back of a classroom and used a checklist to record all aspects of teaching and learning.

Data analysis

The semi-structured interview data analysis was done according to Attride-Stirling's (2001) thematic network. The following figure depicts how data were analysed in this study. The thematic network analysis was applied to explore and identify similar patterns in the data collected.

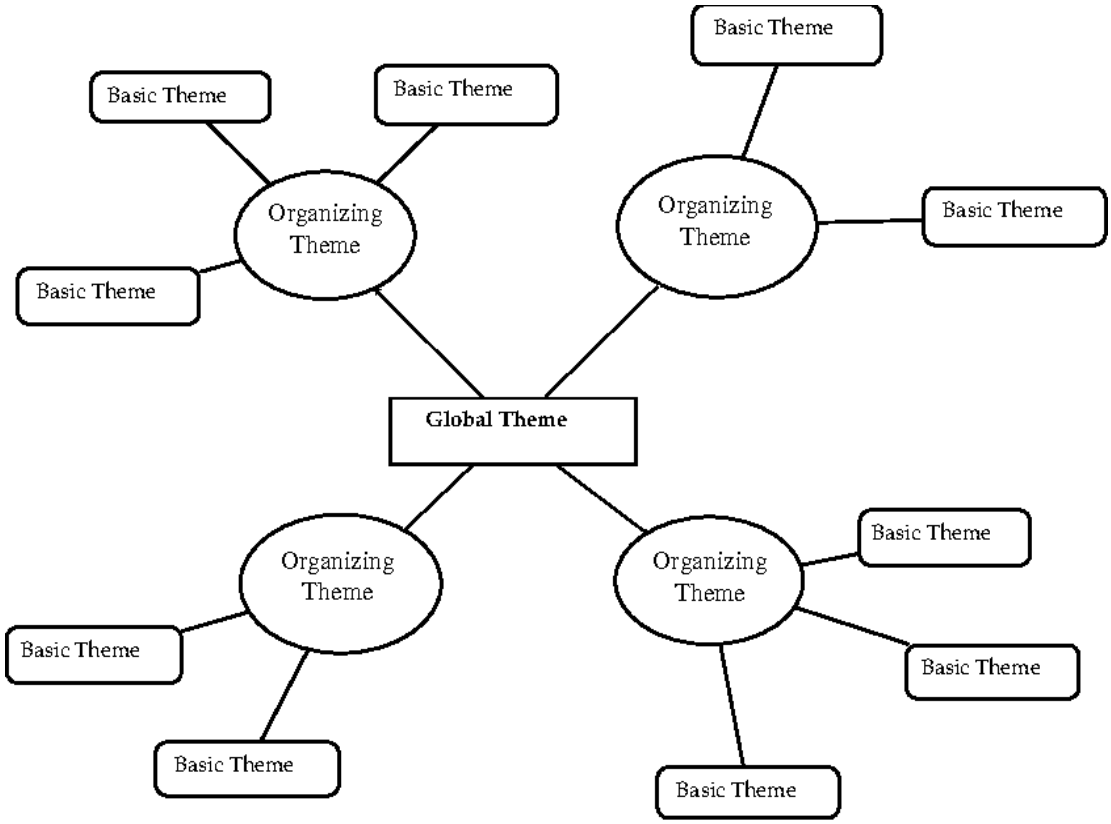

Figure 2: Attride Stirling (2001) thematic network data analysis diagram

The thematic network used for analysis of the data on teachers' enhancement of learning outcomes using digital technology is shown in Figure 3 below.

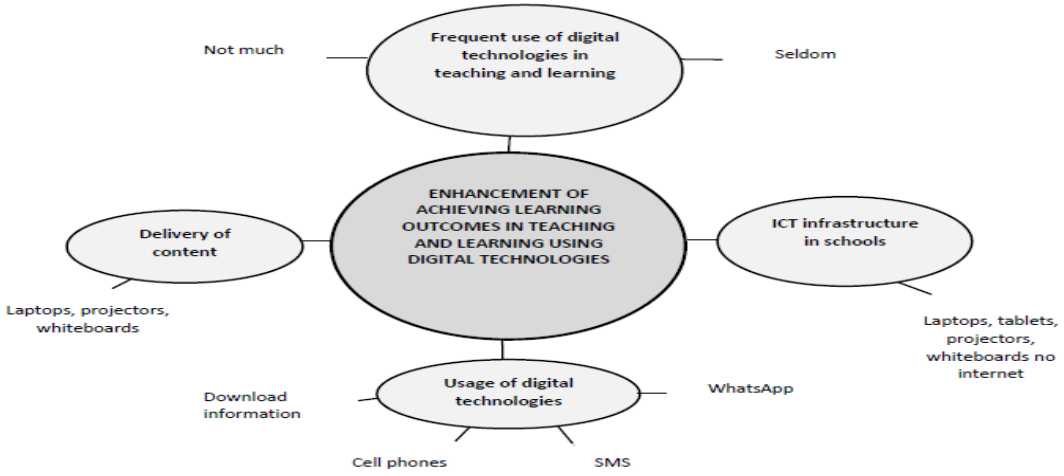

Figure 3: Thematic network of teachers' enhancement of learning outcomes using digital technology.

The data were analysed using two global themes, from which four organising themes emerged. Different basic themes also emerged as the analysis of data unfolded.

RESULTS

Question 1: How do grade 9 secondary schools' teachers use the digital devices to deliver subject content?

The frequent use of digital technologies in teaching and learning was the first organising theme that emerged. The findings revealed most of the participants seldom used digital devices in delivering their subject content. Some did not make use of digital devices in their content delivery. Limited use of technology implies limited technological knowledge. One participant noted:

> *Not often, I may say, usually I use video lessons during revisions. During revisions it is usually by the third term, starting from the third term.* (T31)

The second organising theme, ICT infrastructure in schools, revealed that all the participants indicated the availability of laptops, tablets, projectors and whiteboards but no Internet connection. Most of the teachers said they use a data projector and laptop to present their lessons, the following excerpt refers:

> *We do have projectors or sometimes educators can also use laptops.* (T32)

> *The problem is connectivity and at the beginning especially data, right now we are having a committee but even if we send something on the group, they cannot, not all of them can learn because they cannot afford it.* (T30)

The use of digital technologies emerged as the third theme and has revealed that some participants used various teaching strategies to deliver content using digital devices. One participant created a WhatsApp group to interact with learners about scholastic information. The other participants used SMSs to remind learners of homework and other related schoolwork. Some of the participants used their own data bundles to download information from the Internet to share it with learners when they are offline at school. In the participating schools, learners were not allowed to bring their mobile phones to school. However, if a teacher wants to use mobile phones with learners in a lesson, learners would be requested to bring their phones to school. Participant T28 attests to this as follows:

> *Yeah, normally if maybe I've got some work to do and then I normally send them a telegram SMS because it saves data compared to WhatsApp, so normally I forward the work and then they find that as I have mentioned we've got loads on the laptop.* (T28)

The delivery of content is the fourth organising theme. The findings revealed that the main digital infrastructure or digital technologies that the participants used to deliver lessons were whiteboards, laptops and projectors. Some of the participants struggled to deliver subject content online because their school had only one projector and they had to wait for their turn to use it. The importance of the provisioning of adequate ICT infrastructure was evidenced by a teacher in one of the participating schools who used a projector and a laptop once a month:

> *I said I only use the projector and a laptop once a month and that's when I am using diagrams or explaining what I have to introduce.* (T21)

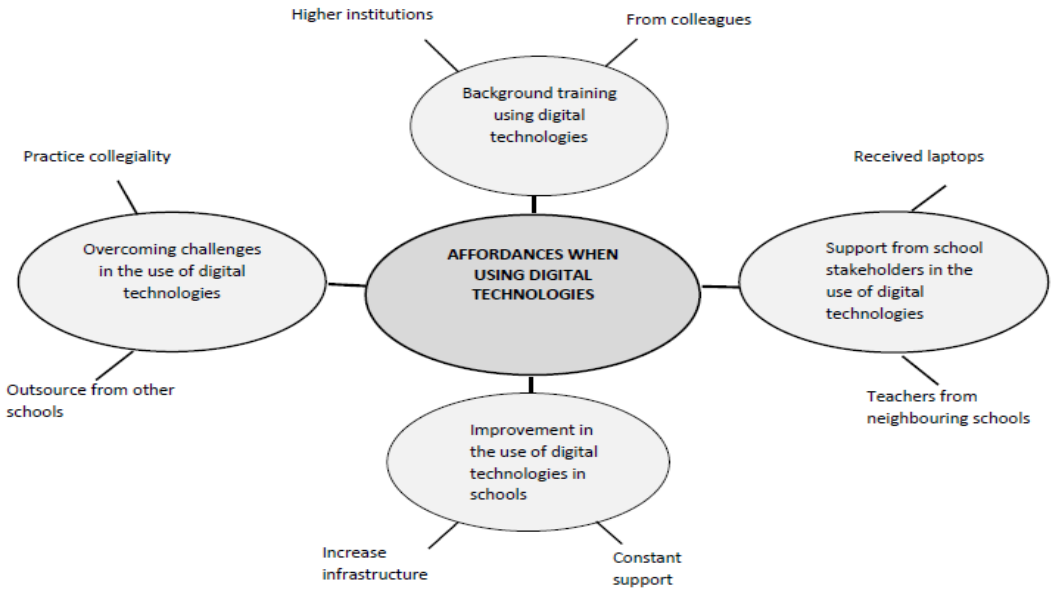

Figure 4: Thematic network for teachers' affordances in using technological devices

The thematic network used for analysis of the data on teachers' affordances in using technological devices is shown in Figure 4 above.

Question 2: How do grade 9 secondary schools' teachers afford to use digital devices to deliver content?

The emergence of background training using digital technologies revealed that most of the participants did not receive any background training to use technological devices. Some of them requested colleagues to assist them with training in delivering content online. Some received ICT training at higher institutions. The excerpt below demonstrates:

> *Not much, it was some time ago when someone from the sub-district came to train us on those boards, how we, I keep forgetting the name, digital technology where you just pointing, clicking and then touching and all those things. We received [training], but not much of a follow-up was made and then you know sometimes they just need to maybe keep on doing it, then from time to time so that you get used to that.* (T31)

With regard to support from school stakeholders in the use of digital technologies, all the participants unanimously attested that they received initial support from neighbouring schools. The views of one of the participants demonstrates below:

> *We have support, it is just that we, after they provided us with the laptop, […] there is no more support that we get.* (T28)

The improvement in the use of digital technologies in schools revealed that all the participants believed in constant support and adequate supply of ICT infrastructure.

Overcoming challenges in the use of digital technologies as another organising theme revealed practising collegiality in the school could be a solution to challenges that may surface. Working as a community of practice with other neighbouring schools could also be something to rely on. One participant commented as follows in this regard:

> *When we are having a technical problem or I am experiencing some problem, we will call, I will call my colleagues to come and fix it.* (T20)

OBSERVATION

Regarding observation, the researcher used a checklist to gather data, and the focus was on the TPACK model. In essence, the focus was on participants' knowledge to select an appropriate technological device for the lessons and how they navigate them, how the participants use technology to deliver content and how they make the content interesting and meaningful using technology.

Technological knowledge

One participant used electric circuit appliances, as the topic the participant taught was electric circuits. Three participants used PowerPoint slides to deliver lessons. Another participant used a Bluetooth recorder, and the last two participants used the traditional method of teaching by using chalkboards.

Technological pedagogical knowledge

In terms of the participants' pedagogical practices, different teaching strategies were used. The participant who taught electric circuits used a traditional method to demonstrate to learners how an electric circuit operates. As the lesson unfolded, more explanations were shared, and learners participated by answering questions only. Of the three participants who used PowerPoint slides, two of them did not use the slide presentation mode but kept on clicking slides one by one until they finished their presentations. This shows limited knowledge of navigating this technological tool. The other participant used a word processing program and as the lesson unfolded, she scrolled through the Word document until the presentation was completed. Another participant used the traditional method of delivering content. He did a lot of talking and learners were just listening and answering questions when the need arose. One of the participants who used a Bluetooth recorder recorded Dr Nelson Mandela's speech about Education, and the learners listened to the recording, and thereafter responded to questions during class. According to the findings, only one participant demonstrated technological pedagogical knowledge, because the delivery of a lesson was done using a technological device and learners were requested to listen to the recording as the listening skill was practised.

Technological content knowledge

Although the delivery of subject content by some of the participants was not technologically focused, the participants showed expertise in the subjects they taught. However, there was limited evidence of making the content interesting through using technological devices. In most cases, transformation of content using digital devices was not in evidence.

DISCUSSION

On the one hand the delivery of content using digital devices is integral as it empowers learners with capabilities for better understanding of the subject content. On the other hand, digital devices optimise teachers' effective content delivery and attainment of the learning outcomes. In essence

the practical implication of enhancing the achievement of learning outcomes, is integration of digital devices in delivery of content (Kim et al. 2021).

Moreover, online delivery of content is dependent on the availability of ICT infrastructure. The provisioning of all the digital devices in schools is one of the foundations of getting online delivery of content off the ground. The researchers emphasised the need to address infrastructural ICT limitation (Mhlanga & Moloi 2020; Kim et al. 2021). Teachers' perception of using digital devices in subject content delivery plays a crucial role as their perception can contribute to the success and efficient use of digital devices (Dong & Mertala 2021). The use of digital devices after COVID-19 ushered in a swift change in the teaching fraternity that would require teachers to have a sophisticated set of digital competencies as earlier proposed by Redecker (2017). Ideally teachers are forced to join the digitalised daily life of learners to overcome intimidation of learners' technological savvy knowledge (Livari, Shama, & Venta-Olkkonen 2020).

The support in terms of regular training to teachers unlocks learners' wealth of opportunities in their lives. This would also assist them, to be on par with new technological developments around the globe. Garba, Byabazaire, & Busthami (2015) shared the same perspective when they contended that training teachers in online teaching should be coupled with ICT literacy skills to be competent users of technology. In line with this, the TPACK knowledge types should also be part of training to guide the effective integration of technology into teaching and learning (Swallow & Olofson 2017). Constant support can be in the form of follow-ups after training to ensure that online delivery of content is done. Pittman & Gaines (2015) emphasised that online teaching and learning skills required educational stakeholders' intervention and support. The intervention and support should be an ongoing process for content delivery to be realised.

Similarly, the integration of digital devices into pedagogical practices transforms the content delivery. However, there is a need for support to fully embark on this progressive journey of online delivery of content (Gunu et al. 2022). The understanding of the capabilities of digital devices alleviates challenges that might be experienced by teachers. Working as a community of practitioners with other neighbouring schools could also be something to rely on.

Observation

Teachers as users of technological devices should be able to demonstrate their technological savvy skills as part of Technological Knowledge (Inpeng & Nomnian 2020; Swallow & Olofson 2017 Taopan et al. 2020) in delivering content. In addition, they should be on the lookout for the new strategies in Technological Pedagogical Knowledge for the delivery of content using technology, with the assistance of a mentor who helps learners to achieve the learning outcomes. Swallow & Olofson (2017) and Taopan et al. (2020) emphasised that teachers should be able to integrate technology into a teaching method used. Teachers' understanding of how to manipulate subject content using technology as part of Technological Content Knowledge is key (Inpeng & Nomnian 2020; Swallow & Olofson 2017; Taopan et al. 2020), as learning would be meaningful and more understandable.

RECOMMENDATION

It is recommended that ICT infrastructure be a priority in helping teachers to learn and use the TPACK model in each of their schools for effective delivery of content. Training in the use of digital devices should be an ongoing process to aid teachers' understanding of the growth in the field of educational technology. Technological information and skill should surpass all other information sharing for educational technologies and taking each by hand would realise use of the TPACK model.

CONCLUSION

This study explored secondary school teachers' use of the TPACK model in delivering subject content after the COVID-19 pandemic disruption threat. The findings showed that the use of digital devices enhances the achievement of learning outcomes. Provisioning of ICT infrastructure (Technological Knowledge) limits the delivery of content, especially unavailability of Internet connection in participating schools. Data projectors and laptops are the only digital devices mostly used in all participating schools. Non availability of digital devices exacerbated challenges in content delivery (Technological Content Knowledge). Training of teachers on the use of digital devices remains a core route that enables teachers to deliver content effectively using technology (Technological Pedagogical Knowledge). Cooperative teaching among teachers goes a long way, as it minimizes working in silos. It promotes achievement of the school's ICT goals of using teamwork. The challenges that occur can be addressed by collegiality that would be a best practice for schools.

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