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# Adapting to Remote Teaching: Experiences and Technological Adjustments of Rural Physical Science Teachers During the COVID-19 Pandemic

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**ABSTRACT**

The COVID-19 pandemic necessitated an abrupt shift to remote teaching, presenting unique challenges for rural Physical Science teachers due to their limited access to technological resources. This qualitative study employed a phenomenological approach to explore the lived experiences of six Physical Science teachers from rural South Africa during this transition. Data were gathered through semi-structured interviews, classroom observations, and document analysis. The findings reveal significant disruptions in teaching and learning processes, with a pronounced negative impact on student engagement and learning outcomes. The study highlights teachers' adaptative measures, including using WhatsApp and other digital platforms to mitigate educational interruptions. Despite their efforts, the lack of infrastructure and digital tools severely restricted effective teaching. This research highlights the necessity of enhanced technological support and resources for rural educators to ensure resilient and adaptable educational practices in the face of future disruptions. The experiences detailed herein reflect broader implications for policy and practice, advocating for a strategic focus on closing the digital divide and supporting rural educators comprehensively.

**KEYWORDS**

COVID-19 pandemic; remote teaching; rural education; phenomenological study; physical science.

## INTRODUCTION

The COVID-19 pandemic caused significant educational disruptions, forcing teachers worldwide to quickly adjust to remote and hybrid learning settings (Bozkurt et al., 2020; Li et al., 2021). Teachers in rural areas faced significant challenges during this global shift, as they often had limited access to technological resources (Bekereci-Şahin & Savaş, 2022; Dube, 2020; Kemaloglu-Er & Sahin, 2022; Kusuma, 2022). Physical Science teachers encountered unique difficulties among these teachers, primarily stemming from the practical and experimental nature of their subjects. This study investigated the experiences and technological adjustments made by Physical Science teachers in rural areas during the COVID-19 pandemic. It examined the impact of these adjustments on their teaching methods and how they, in turn, influenced student engagement and learning outcomes.

Rural Physical Science teachers often encounter unique challenges that can make teaching more difficult (Osman & Kriek, 2021). These challenges may include limited access to resources like lab equipment and technology and a lack of professional development opportunities (Basson & Kriek, 2012). Additionally, rural schools may struggle to attract and retain qualified teachers in the Physical Science field, leading to high turnover rates and inconsistent instruction for students (Torres-Blue, 2019). Despite these obstacles, rural Physical science teachers play a crucial role in providing students with a strong foundation in scientific concepts and the skills necessary for future success in STEM fields. Stakeholders need to recognize teachers' unique challenges in rural areas and provide adequate support and resources to help overcome these obstacles (Li et al., 2021). By investing in professional development opportunities, improving access to necessary resources, and addressing teacher retention issues, rural schools can effectively equip their Physical Science teachers to educate and inspire students (Torres-Blue, 2019). Ultimately, by supporting and empowering teachers in rural areas, we can ensure that all students have access to quality science education regardless of their geographic location.

In addition to providing support and resources for teachers in rural areas, it is also crucial to emphasize the importance of technological adaptations in teaching (Adarkwah, 2021). With advancements in technology constantly evolving, integrating digital tools and resources into the classroom can greatly enhance the learning experience for students (Haleem et al., 2022). By utilizing online simulations, virtual labs, and interactive multimedia presentations, Physical Science teachers can make complex concepts more accessible and engaging for their students (Hamed & Aljanazrah, 2020). Furthermore, technology can also facilitate communication and collaboration among teachers, allowing them to share best practices and resources to improve their teaching practices (Adarkwah, 2021). In this digital age, embracing technological adaptations in teaching is essential to ensuring that all students have the opportunity to receive a high-quality science education (Haleem et al., 2022).

Furthermore, technology can also provide personalized learning opportunities for students, allowing them to progress at their own pace and focus on areas where they may need

additional support (Bingham et al., 2018; Solas & Sutton, 2018). This individualized approach can help students build confidence in their understanding of scientific concepts and improve their general academic performance (Alamri et al., 2020). By incorporating technology into their teaching strategies, Physical Science teachers can create a more inclusive and dynamic learning environment that caters to the diverse needs of all students (Ng & Fergusson, 2019). Ultimately, the integration of technology in education is vital for preparing students for success in an increasingly digital and technological world (Bingham et al., 2018).

Extensive documentation highlights both the resilience and challenges teachers face globally during the rapid shift to online and remote learning during the COVID-19 pandemic. Literature on this transition has predominantly concentrated more on urban educational settings, where technological access and literacy are relatively higher (Smith et al., 2024; Sun et al., 2022). However, the experiences of rural teachers, especially those teaching complex subjects such as Physical Sciences, remain underexplored. This gap is particularly pronounced in understanding how these teachers adapted their teaching methodologies amidst technological constraints. This is why this study sought to address the research question below.

*How did rural Physical Science teachers' experiences and technological adaptations during the COVID-19 pandemic influence their teaching?*

## LITERATURE REVIEW

### *Challenges faced by rural teachers*

The challenges teachers encounter in rural schools are complex and substantially impact the quality of education provided in these regions. The predominant issue at hand is poor working conditions, marked by a lack of essential teaching resources, excessive teaching and administrative responsibilities, and insufficient funding for schools (Li et al., 2021; Shikalepo, 2020). The absence of crucial infrastructure and adequate financial backing significantly impedes teachers' capacity to deliver effective education. Moreover, administrative obstacles in hiring teachers, coupled with the requirement for teaching multiple grades without adequate training, worsen the challenges faced by rural teachers (Marwan et al., 2012; Mulkeen & Chen, 2008).

Inadequate training of teachers further compounds the issue (Shikalepo, 2020). Many teacher training programs fail to adequately prepare teachers for the unique challenges of rural teaching environments, resulting in a significant number of teachers lacking the necessary skills to improvise and utilize instructional materials effectively (Adedeji & Olaniyan, 2011; Alam & Farid, 2011). Additionally, there is a dearth of professional development opportunities in rural areas, making it difficult for teachers to enhance their competencies and adapt to the specific needs of their students (Shikalepo, 2020; Zorba, 2022). The migration of qualified teachers to urban areas, where professional and personal opportunities are more abundant, leaves rural schools with a shortage of adequately trained staff (Marwan et al., 2012; Ncube, 2013).

Isolation is another critical challenge for rural teachers, affecting both their professional and personal lives. The physical remoteness of rural schools limits teachers' access to

professional development activities and essential services such as banking, healthcare, and recreational facilities (Shadreck, 2012). This isolation not only diminishes their opportunities for career advancement but also impacts their overall quality of life, leading to job dissatisfaction and higher turnover rates (Redding & Walberg, 2012). The social isolation experienced by teachers, coupled with the lack of support services, further undermines their ability to deliver high-quality education (Giordano, 2008).

***The use of technology in science education***

In recent years, a significant focus has been on incorporating technology into science education. Technological advancements present distinct opportunities to improve the instruction and comprehension of scientific principles, offering interactive, fascinating, and efficient educational experiences. An essential benefit of incorporating technology in science education is its capacity to captivate and inspire students (Adarkwah, 2021). Interactive tools, such as simulations, virtual labs, and educational games, enhance the learning experience by making it more dynamic and enjoyable (Dustman et al., 2021). Research has demonstrated that virtual laboratories can accurately replicate actual experiments, enabling students to investigate complex scientific phenomena without the limitations of tangible materials (Artun et al., 2020). These tools engage students and offer them practical experience, promoting a more profound comprehension of scientific concepts (Dagdilelis, 2018; Dustman et al., 2021).

Technology facilitates individualized learning experiences suited to individual student's specific needs and learning speeds (Bingham et al., 2018). Adaptive learning systems and educational software have the ability to evaluate students' advancement and offer customized feedback and resources (Bingham et al., 2018). This individualized approach guarantees that students receive the necessary assistance to comprehend scientific concepts fully, ultimately enhancing their learning achievements (Alamri et al., 2020). In addition, technology facilitates differentiated instruction, enabling teachers to cater to a wide range of learning styles and abilities in the classroom (Smith et al., 2024).

Although there are potential advantages, incorporating technology into science education is not without difficulties. Access and equity issues continue to pose substantial obstacles (Dube, 2020; Kusuma, 2022). Students from economically disadvantaged backgrounds or schools with limited resources may face barriers to accessing essential technological devices and internet connectivity, which can hinder their ability to fully utilize digital learning tools (Shikalepo, 2020). The existence of this digital divide can worsen educational disparities and impede efforts to offer a fair and equal science education to every student.

***Impact of technology on teaching effectiveness***

The integration of technology into education has transformed teaching and learning methods around the world. It is essential to comprehend the influence of technology on teaching effectiveness as it becomes more integrated into educational practices (Kumar et al., 2022). The ongoing development of technology has greatly enhanced the efficiency and effectiveness of instructional delivery (Johnson et al., 2021). Digital tools like interactive whiteboards,

multimedia presentations, and educational software enable dynamic and engaging teaching methods (Maher et al., 2012). These tools facilitate teachers in visually and interactively presenting intricate concepts, accommodating various learning styles, and enhancing student comprehension (Maher et al., 2012). For instance, using multimedia resources, which integrate text, images, and audio, can augment comprehension, enabling students to grasp abstract concepts more tangibly.

The introduction of technology in education has significantly enhanced the availability of a wide variety of resources (Clunie et al., 2018). Online databases, educational websites, and digital libraries offer teachers extensive information and teaching resources (Maher et al., 2012). This access enables teachers to enrich their instructional plans with current information and diverse content, thereby enhancing the quality of education (Kumar et al., 2022). In addition, technology facilitates the utilization of open educational resources (OER), which are readily available and can be customized to suit specific instructional requirements (Mićunović et al., 2023). Furthermore, technology promotes collaborative learning by facilitating communication and interaction among students as well as between students and teachers (Dustman et al., 2021). Learning management systems (LMS), online discussion forums, and collaborative software platforms enable and support group work and peer learning (Maher et al., 2012). These tools promote student interaction, knowledge sharing, and project collaboration, thereby improving their learning experience and cultivating a sense of community (Smith et al., 2024; Tarman, 2016).

## THEORETICAL FRAMEWORK

Phenomenology was chosen as a framework to guide this study as it seeks truth in people's accounts based on their lived experiences of the phenomenon under investigation (Williams, 2021). It emphasizes understanding and expressing what individuals perceive, sense, and are aware of from their experiences (Dangal & Joshi, 2020). The primary aim of phenomenological research is to fully comprehend, characterize, and capture the essence of participants' lived experiences with a particular occurrence. This framework was particularly relevant for studying the experiences of rural physical science teachers who had to adapt to remote teaching and make technological adjustments during the COVID-19 pandemic. The phenomenological framework's focus on experiences, such as lived experience, intentionality, phenomenological reduction, imaginative variation, and the role of co-researchers, made it the most suitable choice for this investigation (Yüksel & Yıldırım, 2015).

To understand the experiences of these teachers, several phenomenological concepts are considered (Dangal & Joshi, 2020). Lived experience captures the unique experiences of individuals on the same phenomenon, highlighting the varied experiences of rural teachers adapting to remote teaching. Intentionality refers to the deliberate actions and decisions that teachers make regarding the use of technology. Imaginative variation is about looking at the phenomenon by questioning and getting rid of unnecessary parts (Yüksel & Yıldırım, 2015).

Lastly, the concept of co-researchers recognizes participants as essential contributors to the research, as their perceptions and experiences form the essence of the phenomenon studied.

## METHODOLOGY

### *Research Design*

This research study aimed to explore the experiences and technological adjustments made by Physical Science teachers in rural areas during the COVID-19 pandemic. A case study design was used to explore these experiences in addition to a phenomenology framework. The case study design was best selected for this study because it gave the researcher in-depth knowledge of the phenomenon being investigated (Creswell, 2014). Each participant teacher was considered a case studied within its context to avoid any theoretical assumptions that the researcher might make. The interpretative research paradigm was utilized to guide the methodological framework of this study. The interpretative research paradigm takes into account the participants' personal and interpersonal views as they interact with the world around them (Pervin & Mokhtar, 2022). This paradigm tries to get into the participant's situation to understand and interpret their meaning within their context (Kumatongo & Muzata, 2021; Makhubele, 2016). The researcher tried to comprehend the experiences of Physical Science teachers when using technology for teaching during the COVID-19 pandemic.

### *Participants*

The study focused on six secondary Physical Science teachers in the Makhutswe circuit, Mopani West District, Limpopo province. The teachers received invitations to participate in the study through a series of phone calls and invitation letters. The study used the following criteria to select the teacher participants: a) The participant must be from a rural area; the researcher chose this criterion to explore how participants navigated the use of technology with limited technological resources, poor network coverage, and a lack of electricity during the COVID-19 pandemic; b) The participants must be teaching Physical Sciences in FET phase, this criterion was chosen to ensure that the participants are informed about the subject matter hence they would know when it is necessary to use technological tools for teaching; c) The participant must be willing to participate in the study, this was chosen to respect the participants' consent rights. The selection of these criteria was mainly to share insight into how physical science teachers in rural areas dealt with the use of technology during the COVID-19 pandemic. Furthermore, the selection was made to possibly bring awareness to the Department of Education of the need to amend the educational policies regarding the use of technology to cater to teachers in rural areas.

Six physical science teachers from six different high schools were selected and consented to participate in the study. Convenience sampling was used to select the participants. Convenience sampling is a non-random method where the participants are selected because they meet a certain criterion (Obilor, 2023). The criteria may include easy accessibility, geographical proximity, availability at a given time, or willingness to participate in a study. A

small sample size was chosen based on this study's context and paradigm. The study used an interpretative paradigm requiring in-depth analysis; hence, a small sample was necessary to avoid findings saturation. The participants' ages range from 30-55 years. This age range was necessary to provide different experiences for teachers. Studies show that age is one-factor affecting teacher integration of technology in the teaching space (Spiteri & Chang Rundgren, 2020).

The ethical guidelines, as stated by the University of South Africa and the Limpopo Department of Education, were followed, and ethical clearance was granted. Participant information letters and consent letters were provided to the selected teachers to give consent to participate in the study. The participants were informed that their real names would not be used, but pseudonyms. Furthermore, the participants were notified that their participation was voluntary and that they had the right to withdraw from the study when they no longer wanted to participate. Table 1 below shows detailed information about the participants.

**Table 1.**

*Participants in the study*

| Participants pseudonyms | Qualifications | Age range | Years of teaching experience | Schools' pseudonyms |
|---|---|---|---|---|
| John | Diploma specializing in physical science and natural sciences | 45-50 | 20 | Dinaledi |
| Katlego | Bachelor of Science honors degree and postgraduate certificate in education specializing in physical sciences | 30-35 | 9 | Remmogo |
| Tebatso | Bachelor of Education specializing in physical sciences and life sciences | 25-30 | 3 | Reatlegile |
| Thabo | Bachelor of Science degree and a postgraduate certificate in education | 35-40 | 4 | Hope |
| Lebo | Bachelor of Science degree and a postgraduate certificate in education | 30-35 | 7 | Faith |
| Peter | Diploma in education specializing in physical sciences | 50-55 | 18 | Grace |

***Data collection process***

To explore the experiences of teachers teaching physical sciences during the COVID-19 pandemic, three different techniques were used to collect data: semi-structured interviews, classroom observation, and document analysis.

*Semi-structured interview*

The researcher started the process by explaining to the participants the purpose of the interviews and urging them to feel free to participate. The researcher proceeded to ask them for permission to record the process. All the participants were interviewed; therefore, six face-to-face, semi-structured interviews were conducted. The researcher found the face-to-face interviews beneficial for this study because they gave a profound understanding of the phenomenon. Furthermore, it allows for the build-up of a faster yet more efficient and smooth assessment process while enabling a thorough data collection process (Saarijärvi & Bratt, 2021). The semi-structured interviews consisted of only questions that sought to clarify the investigation. The interviews lasted for 20-35 minutes. This was done to allow the participants time to respond freely without feeling pressured. Each teacher was interviewed once before they could be observed in a classroom setting for convenience reasons.

*Classroom observation and document analysis*

Six lessons conducted by teachers were observed. Each observation lasted for 30-60 minutes. The observations were done once per teacher. The observation template was used and included, among other things, the classroom setting and whether the classroom allowed for the connection of technological tools. Furthermore, was the teacher in possession of any technological tools? If so, how effective and efficient was the tool used during the lesson presentation? Moreover, was the teacher prepared to use the tool for teaching? Through these questions, the researcher could fill in the observation template and gather relevant information for the investigation. The researcher was able to understand the phenomenon being observed at a deeper level.

Lesson plans were collected at the end of lesson presentations. The lesson plans were used to determine the types of technological tools that were listed and to confirm if they were used during the lesson. Furthermore, the lesson plans were used to check if the teaching and learning objectives were covered. Moreover, through lesson plans, the researcher could find, select, make sense of, and synthesize data (Armstrong, 2020).

***Data analysis***

Thematic analysis was used to analyze the data collected in this study. Thematic analysis was chosen best for its flexibility in terms of (a) the type of research questions it can address, from personal accounts and understandings to broader social contexts; (b) the type of data and documents examined; (c) the volume of data analyzed; (d) the choice of conceptual framework applied; and (e) the ability to analyze data with an inductive approach (Kiger & Varpio, 2020). The analysis began with the researchers transcribing the audio recordings from the interviews

and reading through the observation schedule and lesson plans, with the aim of becoming familiar with the entire dataset.

Codes from the dataset were generated systematically, with the researchers labeling the potentially relevant features to the research questions. The codes aimed to identify different elements of the data set, including teachers' understanding of technology use, the types of technological tools used for teaching, and the challenges they encountered when using these tools. Furthermore, the codes highlighted the impact of COVID-19 on the use of technology for teaching.

The coded data was studied with a search for themes to classify the resemblance and extent of the codes. The researcher created themes and sub-themes by grouping the codes that appeared to share common features. This was aimed at reflecting and defining clear and meaningful patterns of data. Furthermore, the researchers reviewed the developing themes from the coded data and the entire dataset. This was done to check if there were codes that were not working with the data; if so, the researchers discarded them or moved them under other themes. Moreover, extracts from the dataset were selected and analyzed to set out a story for each theme, and the researchers wrote a report to give a persuasive story about the data according to the researchers' analysis (Kiger & Varpio, 2020).

Braun and Clarke (2023) state that thematic analysis is associated with qualitative research. The audio recordings in this study were transcribed verbatim. Therefore, to ensure the reliability of the data and methodological rigor, transcripts were shared with the participants to ensure accuracy. The analysis sought to bring clear and structured representations of patterns and insights into the collected data. The following themes emerged from the dataset: a) The impact on teaching and learning, b) Technological adaptations, and c) The use of technology in lessons.

## RESULTS

The data analysis revealed several key themes regarding rural Physical Science teachers' experiences and technological adaptations during the COVID-19 pandemic. These themes include the impact on teaching and learning, technological adaptations, and the use of technology in lessons.

### *Theme 1: Impact on Teaching and Learning*

*Case 1: John*

John reported that during the initial stages of the COVID-19 pandemic, there was a complete stop in teaching and learning activities at his school. He stated the following:

Researcher: *During the COVID-19 pandemic, was teaching and learning taking place in your school*?

John: "…*no it was not until when it was open for us to have schools that we were able to do that. So, when it was still harsh the schools were closed, and we were not having lessons*".

This lack of engagement significantly negatively impacted students' performance in Physical Science, according to John. John mentioned that the practical nature of Physical Science requires constant engagement, which was disrupted during the lockdown: "…*we did not perform very well hence I said Physical Science needs to be more practical and the other thing is learners need to be doing things almost every day so because of let's call it 'stay away' it has impacted much on the performance of learners*".

*Case 2: Katlego*

Katlego reported that no teaching or learning took place during the COVID-19 lockdown in his school due to the lack of technological devices among learners. He pointed out, "…*the reason has been ermh! As simple as learners having smartphones. Learners were not having smartphones and they were not allowed to move to go anywhere*". This lack of engagement led to incomplete syllabus coverage and poor performance in Physical Science. Katlego commented, "…*the performance of Physical Science subjects was negatively affected because learners did not do all the chapters. We did not have time anymore and the performance was low the learners failed*".

*Case 3: Tebatso*

Tebatso indicated that although some form of teaching and learning was taking place via WhatsApp, it was not entirely effective due to challenges such as poor internet connectivity and a lack of data among learners. He stated:

Researcher: *During the COVID-19 pandemic, was teaching and learning taking place in your school*?

Tebatso: "…*it was taking place, but it was not that effective as such when we were home, I was giving learners activities as per different topics then as you give them activities to conduct while they were at home you find that erh! In some cases, learners don't have data to access the activities*".

*Case 4: Thabo*

Thabo reported that he continued teaching through WhatsApp, which facilitated discussions and activities. He emphasized the importance of continuous learning in Physical Science due to its cumulative nature. Thabo said, *"…yes, I was teaching online using the WhatsApp platform. I was telling the learners that we will be discussing this at this time and at that time we log in and introduce the topic and ask them questions some will respond either at the time or they will record voice notes".*

*Cases 5 and 6*

Lebo (case 5) reported that no teaching and learning occurred during the COVID-19 lockdown, which had a detrimental effect on students' performance, particularly in lower grades. She noted, "…*for lower Grades such as 10 & 11 it has affected them badly because we went back to school and focused only on Grade 12*". Peter (case 6) resorted to using WhatsApp for teaching and assessments during the lockdown. He highlighted the challenges faced by students in adapting to online learning. Peter pointed out, "…*I was sometimes using WhatsApp to talk to*

*the learners at home. I believe learners must have tablets and Wi-Fi so that they can do their own research*".

***Theme 2: Technological Adaptations***

*Cases 1 and 2*

John (case 1) emphasized the necessity of technological tools for continued learning during the COVID-19 pandemic. He suggested that if learners had been provided with gadgets such as tablets and internet connectivity, similar to initiatives in Gauteng province, they could have continued their studies remotely. He said, "…*if learners had those tablets or access to cell phones and data, we can be able to do online teachings. Learners would not have stayed for a long time out of school*". Katlego (case 2) highlighted the critical role of smartphones and other devices in facilitating remote learning. However, the absence of these tools in his school severely hampered the continuation of education during the COVID-19 lockdown.

*Cases 3, 4 and 5*

Tebatso (case 3) adapted WhatsApp to distribute assignments and engage with students. Despite the challenges, this method allowed some level of continuity in education. Thabo (case 4) effectively used WhatsApp to maintain interaction with his students. He recognized the importance of this medium in preventing content gaps and ensuring students remained engaged with their studies. The lack of technological tools at Lebo's (case 5) school meant there were no alternative methods to continue teaching during the lockdown, leading to significant learning gaps.

*Case 6: Peter*

Peter emphasized the necessity of providing students with tablets and Wi-Fi to facilitate effective online learning. Despite using WhatsApp for teaching, he acknowledged the limitations and challenges associated with online education.

***Theme 3: Use of Technology in lessons***

*Case 1: John*

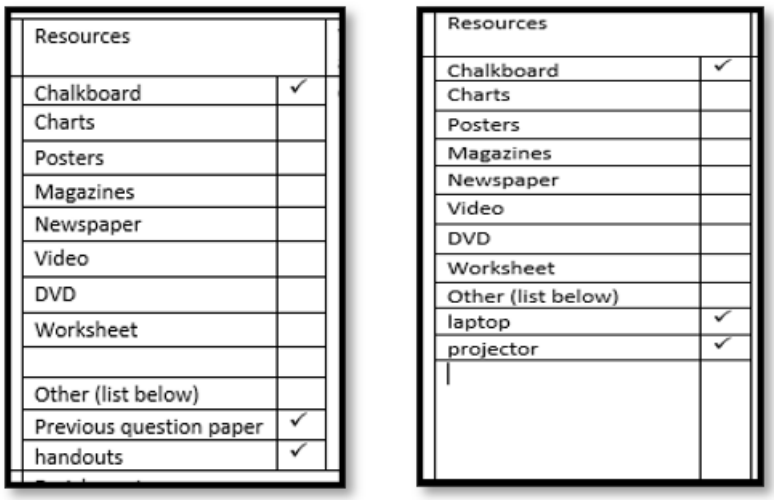
John utilized available technology in his teaching, including laptops, projectors, and Wi-Fi connectivity, which he noted were essential for lesson delivery. During a classroom observation, he was seen setting up a laptop and projector, which, although time-consuming, were crucial for his lesson presentations. Figure 1 shows part of the lesson plan, which indicates the resources John used during his lesson presentation.

*Case 2: Katlego*

During classroom observations, Katlego was seen using traditional teaching tools such as chalk and previous question papers, indicating a lack of technological integration in his teaching practices. Figure 1 below shows part of the lesson plan, which indicates the resources Katlego used during his lesson presentation.

***Figure 1.***

*Resources used by John (left) and Katlego (right) during their lesson presentations.*



| Resources | |
|---|---|
| Chalkboard | ✓ |
| Charts | |
| Posters | |
| Magazines | |
| Newspaper | |
| Video | |
| DVD | |
| Worksheet | |
| | |
| Other (list below) | |
| Previous question paper | ✓ |
| handouts | ✓ |

| Resources | |
|---|---|
| Chalkboard | ✓ |
| Charts | |
| Posters | |
| Magazines | |
| Newspaper | |
| Video | |
| DVD | |
| Worksheet | |
| Other (list below) | |
| laptop | ✓ |
| projector | ✓ |

*Cases 3, 4 and 5*

Tebatso (case 3) mentioned using laptops and projectors in his school to enhance lesson delivery. He noted, "…*Erh! Where am based there are only everyone is given a laptop, or we have the laptops erh! we have the overhead projector sometimes they are connected to share some videos with learners trying to clear up some misconceptions*". Thabo (case 4) utilized laptops and projectors during his lessons, acknowledging their importance in delivering comprehensive educational content. Lebo (case 5) did not utilize any technological tools during her lessons. She taught the lesson using traditional instructional techniques without employing any technological resources.

*Case 6: Peter*

During the classroom observation, Peter used a laptop and projector during his lessons, although he faced difficulties in setting up these devices, indicating a need for better infrastructure and support for technological integration in teaching.

## DISCUSSIONS

The experiences and technological adaptations of rural Physical Science teachers during the COVID-19 pandemic profoundly impacted their teaching methods and the educational outcomes of their students. The themes that emerged from the data impact on teaching and learning, technological adaptations, and the use of technology in lessons highlight both the challenges and opportunities presented by the COVID-19 pandemic.

The sudden shift to remote learning disrupted traditional teaching methods, particularly in subjects such as Physical Science that require practical and hands-on engagement. Teachers

such as John and Katlego reported a significant decline in student performance due to the lack of in-person instruction and practical exercises. This is consistent with Sintema (2020), who noted that reduced contact time and the absence of e-learning resources adversely affected student outcomes in science subjects. This radical shift has not only affected students but teachers as well. Teachers had to plan and design lessons, class activities, and assessments suitable for remote teaching with little or no training in using technology for teaching (Winter et al., 2021). This was evident as Peter was faced with difficulties setting up the technological devices during the lesson presentation.

The incomplete coverage of the syllabus and the resulting knowledge gaps were significant concerns. Winter et al. (2021) argue that the move to remote teaching has resulted in learning loss for students due to confusion, lack of motivation, and less time spent on learning. Katlego and Lebo highlighted that those students in lower grades suffered the most, as they missed critical foundational content. This further aligns with findings by Haleema et al. (2022), who argue that the shift to online learning created substantial barriers for students, particularly those lacking technological resources.

The pandemic emphasized the importance of technological tools in facilitating continuous learning (Bozkurt et al., 2020; Li et al., 2021). With technology, students may choose when and what to learn, which promotes active involvement as opposed to regular learning (Ilgaz, 2019). Teachers who had access to laptops, projectors, and internet connectivity, such as John and Tebatso, were able to maintain some level of instructional continuity. However, the effectiveness of these adaptations was limited by challenges such as poor internet connectivity and a lack of data among students. Despite connectivity issues, Tebatso's experience of using WhatsApp for assignments mirrors the findings of Winter et al. (2021), who noted that online teaching transformations often resulted in learning loss due to technological barriers.

Additionally, teachers emphasized the necessity of providing students with adequate technological tools. Appropriate technological tools can help students have an improved understanding and retention of information, and on the other hand, knowledge transfer is not only effective but also simple and convenient (Szymkowiak et al., 2021). Thabo and Peter stressed that devices such as tablets and stable internet connections were crucial for effective online learning. This sentiment is echoed by Valverde-Berrocoso et al. (2021), who identified technological mediation as essential for maintaining educational engagement during the pandemic. Furthermore, the integration of technology into lesson delivery varied among the teachers. John and Thabo utilized laptops and projectors to enhance their teaching, recognizing their importance in delivering comprehensive educational content. However, the effectiveness of these tools was sometimes hampered by technical difficulties, as seen in Peter's case.

Technical difficulty makes it difficult to successfully incorporate technology into instruction and deters teachers from implementing technological tools in the classroom (Chisango et al., 2020). This highlights the need for better infrastructure and support for technological integration in rural schools, as Ojo and Adu (2018) recommended. On the other

hand, some teachers, such as Katlego and Lebo, relied on traditional teaching methods due to a lack of technological resources. This reliance on conventional tools during the COVID-19 pandemic further worsened the educational inequalities between rural and urban schools.

## CONCLUSION

Guided by a phenomenological framework, this study sought to understand the lived experiences of rural Physical Science teachers during the COVID-19 pandemic. Phenomenology, with its focus on individuals' perceptions and lived experiences, provided a lens to deeply explore the personal and professional impacts of the pandemic on these teachers. The findings revealed that the lack of technological resources and poor internet connectivity were major barriers to effective remote learning, leading to incomplete syllabus coverage and lower student performance. This aligns with the phenomenological approach, which seeks to understand the essence of experiences from the perspective of those who lived them (Williams, 2021). Teachers' narratives highlighted the emotional and practical challenges they faced, such as feelings of frustration due to inadequate resources and the struggle to adapt to new teaching methods. The findings further revealed a need for proper training and technical support for teachers to use technological tools effectively for teaching.

Teachers who had access to technological tools managed to maintain some level of instructional continuity, though not without challenges. This reflects the phenomenological emphasis on how individuals adapt to and make sense of their circumstances. The use of technology, while beneficial, was also a source of stress due to technical difficulties and the digital divide. The study highlights the critical need for investment in technological infrastructure and training in rural schools to ensure that teachers and students are better prepared for future disruptions. From a phenomenological perspective, this investment is not just about providing tools but also about enhancing the lived experiences of teachers and students, enabling them to navigate and thrive in a technologically advanced educational landscape. The COVID-19 pandemic has shown that while technology can play a crucial role in education, its effectiveness is contingent upon adequate resources and support. This study only focused on six physical science teachers, which is a small sample size, therefore, the results cannot be generalized. However, in a qualitative study, the objective is not to generalize the findings. Hence, the study recommends a quantitative approach to future research on this topic. Furthermore, educational policies should prioritize bridging the digital divide to foster an equitable learning environment for all students, ultimately enhancing the lived educational experiences in rural areas.

### Limitations of the Study

A notable limitation of this study is the reliance on a small and geographically restricted sample of six Physical Science teachers from the Makhutswe circuit in the Limpopo province. This limited sample size and geographic focus restrict the generalizability of the findings, making it difficult to apply the insights to rural Physical Science teachers in different regions or contexts.

This limitation is strengthened by the qualitative nature of the study, which, while providing in-depth and rich data on individual experiences, does not capture the broader spectrum of challenges and adaptations that might be present in a more diverse or larger sample. Consequently, the findings may not fully represent the variety of experiences and technological adjustments made by rural teachers across South Africa or other countries.

**Statements and Declarations**

We have no conflict of interest to disclose.

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