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Teachers' experiences with mathematics online teaching in rural situated primary schools in South Africa

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Abstract

Exploring teachers' experiences with online mathematics teaching in rural primary schools in South Africa reveals a complex picture shaped by various challenges and opportunities. It is critical for mathematics teachers to provide sustainable education that promotes integration of digital technologies effectively into the subject teaching and learning. Underpinned by the self-determination theory, this study used a mixed method approach in which an online survey and semi-structured interviews were conducted with a population of 60 primary school mathematics teachers. This study responds to the question, "What are the teachers' experiences with mathematics online teaching in rural situated primary schools?" Interviews were conducted with a random sample of four teachers selected based on their responses in the survey. Questionnaires were administered to them electronically followed by semi-structured interviews conducted telephonically through WhatsApp with four participants based on their responses in the questionnaire. Results indicate that some teachers prepared MP4 power point video recorded presentations and shared them with their students using the WhatsApp and were able to type mathematics papers. It is recommended that the teachers also need to learn to video-record all their investigations and experiments in teaching STEM subjects.

Keywords: mathematics, learning, WhatsApp, rural schools, MP4 PowerPoint presentations

INTRODUCTION

Mustafa et al. (2024) acknowledge the significant contributions of technology to learning and teaching but notes that there is a well-known technological disparity between schools in rural and urban areas. Jere and Tsoka (2024) highlight the inadequate infrastructure in rural schools that creates educational disparities by limiting access to digital learning tools, disrupting online learning, and hindering teacher proficiency, leading to lower performance and reduced digital literacy for learners especially in mathematics teaching and learning. Furthermore, Choudhary and Bansal (2022) pinpoint the lack of adequate infrastructure, limited digital literacy, and insufficient professional development, resource scarcity, language barriers, including curriculum and workload as some of the challenges that prevail with mathematics teachers in applying online teaching in rural situated primary schools. In addition, Host (2025) acknowledges that the lack of basic technology infrastructure, reliable Internet, sufficient hardware, and digital resources, prevents rural learners from benefiting from the interactive, engaging mathematics education available to their urban counterparts, leaving them unprepared for the demands of modern higher education and the job market. The Alfred Ndzo District in which this study was conducted is not exempted from this. It is predominantly rural and is regarded as the poorest district compared to the others in the Eastern Cape Province of South Africa. Although the department of education has equipped each teacher in primary schools with laptops most teachers are techno-savvy and teach or reside in schools and locations without network coverage, respectively.

This paper reports on the second phase of a project intended to investigate issues of classroom practice in mathematics used, extrapolate, or improve on them for the better development of teachers and learners' meaningful understanding of intermediate and senior phase mathematics in a district in the Eastern Cape

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Contribution to the literature

- This study contributes to the mathematics education literature by focusing on teachers' experiences with mathematics online teaching in rural situated primary schools.
- It provides empirical evidence on explanations of how mathematics education performance has been affected by the digital divide.
- It extends insights into enhancing information and communications technology (ICT) strategies for rural mathematics education in primary schools.

Province of South Africa. In the first phase I visited three schools in the district to observe how teachers present their lessons and the conditions under which they worked. This gave me an idea of the support those teachers needed to teach mathematics effectively. Poverty, lack of infrastructure and technology, clear economic policy and a prevalent unemployment rate characterize the context of primary schools operating in this district. I noticed common features in all three schools like

(1) inadequate access to reliable high-speed Internet although all teachers had cell phones and laptops,

(2) teachers were not capacitated on using those laptops in their lessons, and

(3) could not search for appropriate online mathematics resources on their digital devices.

Haleem et al. (2022) assert that information technology (IT) has emerged to spread shared knowledge and is a primary driving force behind education reforms. Consequently, in phase two of the project, I prioritized equipping the primary school mathematics teachers with basic skills on how to type mathematics papers, find relevant resources for their lessons on the Internet and preparation of PowerPoint presentations. However, Sailer et al. (2021) suggest that the focus should be shifted from classroom equipment to teachers' ability to develop, integrate, share correctly, and use classroom equipment in teaching-learning activities. It was also crucial to ensure that mathematics teachers use open educational resources, to develop their mathematics curricula and assessment strategies. Furthermore, teachers should be able to judge which digital materials might work or might not in their classroom contexts. For example, in such impoverished areas, it is worth doing a survey to check if learners have access to smart phones before sending their mathematics homework digitally. The issues of technological skills and technology affordance in teaching mathematics are prominent in rural situated schools. Underpinned by the self-determination theory (SDT), this study used a mixed method approach in which an online survey and semi-structured interviews were conducted with a population of 60 primary school mathematics teachers. This study responds to the question, "What are the teachers' experiences with mathematics online teaching in rural situated primary schools?"

I will refrain from repeating the considerable evidence pointing to the exploration of mathematics teachers' competence and perceptions of integrating digital pedagogy in rural schools. Such evidence can be found in abundance (Kunwar & Kumar, 2023; Moila, 2024; Mustafa et al., 2024; Naidoo, 2025). What is lacking in the available literature are the explanations on rural primary school mathematics teachers' experiences with online teaching. In the first part of this article, I provide how mathematics education in South Africa has been affected by the digital divide. Next, I venture into information and communications technology (ICT) strategies for rural mathematics education in primary schools. Finally, I will evaluate rural primary school mathematics teachers' perspectives with online teaching.

LITERATURE REVIEW

Globally, the digital divide is a complex issue that intersects with factors such as income, geography, and access to infrastructure. At the national level, South Africa has made strides in addressing digital inequality through initiatives like the "South African Connect" broadband plan, which aims to expand high-speed Internet access. However, this has only benefited citizens in urban areas while rural situated schools and towns cannot access it currently. Faloye and Ajaya (2021) and Isaac and Winke (2024) note that the digital divide significantly affects mathematics education in South Africa by exacerbating existing inequalities and limiting access to quality learning resources and modern teaching methods. These authors define digital divide as a gap between individuals with access and skills to use technology and those without such access and skills due to economic, social, and geographical factors. In some cases, technophobia, broadly defined as the fear related to the use of technology, significantly impedes the ability of individuals to engage with digital tools and platforms especially in rural primary schools where access to technology had been previously a challenge (Faloye & Faniran, 2024). This situation is echoed by the Baudin and Mapulanga (2025) who report that currently, 66% of schools don't have computer centers, and less than 10% of mathematics educators have computers in their classrooms. These authors further caution that without ICT, rural learners miss out on interactive tools like online tutorials and digital games, while educators, who

lack training and resources, are stuck using outdated methods. The key recommendations of the ICT policy in South Africa include revising the ICT infrastructure allocation system, providing qualified IT technicians or training for current educators, specialized ICT training for mathematics educators and developing ICT resources in local languages, to be made available on an easily accessible database. The availability of ICT infrastructure could equip learners in rural schools with interactive educational experiences, such as online tutorials and digital mathematics games, that their urban counterparts enjoy.

In western educational philosophy the idea of digital technology has its genesis in the work of Papert (1991) regarded as a pioneer in integrating digital technology into education. Influenced by the works of Piaget's constructivist theory, Papert (1991) used a constructionist approach and co-invented the Logo programming language, designed to help children learn mathematical and computational ideas through coding. Papert (1993) believed that technology could revolutionize learning by making it more student-centered and exploratory. Sahal and Ozdemir (2023) acknowledge that rural primary schools' mathematics teachers have positive views about using technology and they are willing to use technology classes. This could be associated with the evolution of technology that has broken down barriers and opened a completely new world, with an overabundance of information right at everyone's fingertips (Pletka & Torlakson, 2014). On the contrary, even though during the COVID-19 pandemic, teachers were forced to adapt their usual teaching style to online modes, which are dependent on Internet connectivity and technology, many teachers quickly reverted to their old ways of program delivery in the post-COVID-19 classroom. One could argue that teachers consider the available technology ineffective for enhancing the quality of teaching and learning, particularly in the subjects mathematics, science, and technology.

Digital technology is increasingly being recognized as a powerful tool to support teachers in rural African classrooms. To enhance teaching and learning in rural schools, Ferrentino and Vota (2023) suggests

(1) use of low-cost e-readers that can distribute vast amounts of books in digital formats, promoting literacy and learning,

(2) use of mobile phones to support teachers by providing access to educational resources and facilitating communication with peers,

(3) low cost video technology to support peer learning and teacher training, enabling the sharing of best practices and innovative teaching methods, and

(4) use of digital learning content to provide students in rural areas with access to a wide range of educational resources, including hardware like tablets and educational software for digital learning (Ferrentino and Vota, 2023).

These strategies are yet to be explored in the area in which this study was conducted.

THEORETICAL FRAMEWORK

This study was underpinned by the SDT which promotes effective, sustainable integration of digital technologies in mathematics education by fostering student and teacher autonomy, competence, and relatedness. According to Deci and Ryan (1985), SDT posits that all people have three basic psychological needs:

(1) autonomous where they feel volitional and self-directed,

(2) competency that makes them feel effective and capable, and

(3) relatedness where they feel cared for and connected to others.

It was therefore important in this study to ensure that the participants were trained in how to use their laptops. They committed to a specific course of action which involved learning how to use technology for teaching mathematics in their classrooms and took ownership of the lessons delivered. The skills learnt in the training led them to independence and the participants could function without support (Neufeld, 2025). For students, this means providing digital tools that offer choice, build confidence, and connect them to others, while for teachers, it involves professional development and support that enhances their autonomy, competence, and connection to their peers. Despite increasing recognition of SDT's relevance in mathematics education, educators lack practical tools to translate theory into daily teaching practice. Thus, Kusurkar et al. (2011), Ten Cate et al. (2011), and Earl (2019) argue that SDT informed educational research shows that autonomy, supportive teaching, competence-focused feedback, and inclusive, caring relationships improve learner motivation, engagement and satisfaction. By supporting these fundamental psychological needs, SDT shifts motivation towards intrinsic engagement with digital mathematics resources, leading to more effective learning and sustained use of technology. This would be accomplished when learners are provided with digital tools and activities that give them choices in how and what they learn, allowing them to direct their own mathematics exploration. Teachers should therefore expose them to digital resources while giving them feedback that build their confidence in their mathematics abilities and make the technology to feel like a supportive tool rather than a challenge. Collaboratively learning through digital platforms allows learners to connect with peers and their teachers, while fostering a sense of belonging within the learning community. In

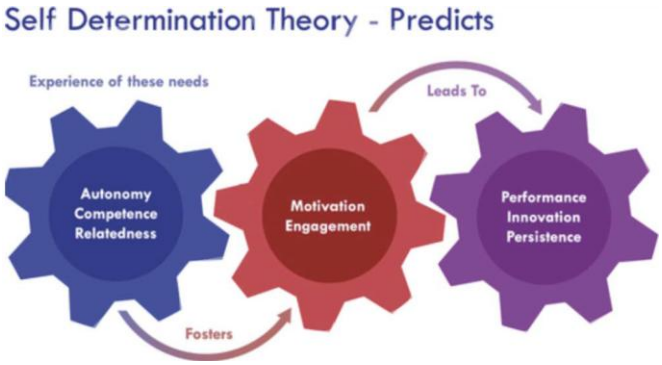

Figure 1. SDT methodology (Adapted from Ross & Scane, 2024)

this study, I strived to equip teachers with the freedom to select and adapt digital tools, such they felt empowered in their technology integration. The workshops conducted with them provided sustained professional development, and ongoing support, that enhanced their skills and confidence in using digital technologies in their classrooms. I also created a WhatsApp platform for them to connect with each other, to share experiences and support, building a network for successful technology integration. Ross and Scane (2024) opine that SDT-based approaches, which focus on fulfilling basic psychological needs, usually lead to more sustainable and effective integration of digital technologies because motivation is driven from within. This is summarized in **Figure 1**.

METHODOLOGY

This article reports specifically on the data collected during the second year of the community engagement project "Bizana teachers' meaningful mathematics teaching and learning processes," targeting 14 primary schools in the Afred Ndzo East District in the Eastern Cape Province of South Africa. The rationale for targeting primary schools that are in the rural setting emanates from the research findings that have persistently linked poor performance in mathematics with disadvantaged socioeconomic communities, such as those characterizing schools in rural settlements. From critical research and interpretivist epistemologies, the paper reports from a mixed methods approach research project that analyzed the experience with online mathematics teaching in rural situated primary schools. I worked with a population of 60 intermediate and senior phase teachers from this district. I used a mixed method approach in which an online survey and semi-structured interviews were conducted with four of those primary school mathematics teachers. In the first phase of this project, teachers received professional development of exposure to various online teaching methods including how they could prepare PowerPoint presentations, outsource mathematics relevant open education resources from the Internet, and sharing lessons with their learners. This study responds to the question, "What are the teachers' experiences with mathematics online teaching in rural situated primary schools?" Questionnaires were administered to them electronically followed by semi-structured interviews conducted telephonically through WhatsApp with four participants based on their responses in the questionnaire. Ethical clearance certificate was sought and granted as No: 2024-7449-9080 from Rhodes university. This study adopted a continuous long-term school-based model where teacher learning was conceptualized as an ongoing process of sense making relating to current practices and the continual refinement of processes together with content to keep pace with the speed of educational landscape changes on digital learning (Engeström, 2001; Johnson, 2010).

RESULTS AND DISCUSSION

The survey results were recorded as responses from the sample frame of 60 participants while interviews were conducted with four teachers based on their responses on the survey. Questions targeted autonomy, competence and relatedness. For autonomy, the focus was on primary school mathematics teachers' freedom, choice, ownership, and ability to make decisions in using digital tools for teaching mathematics. For competence I focused on how confident the teachers were in using digital tools, the skills and resources used, together with training and support received to effectively use technology. It was also important to know the teachers' connection with learners, colleagues, and community through or around their use of technology when teaching mathematics to measure relatedness. Quantitative results from the survey are displayed. In addition, the analysis of qualitative data brought about three themes that related to teachers' experiences with online mathematics teaching in rural situated primary schools. These were: Training on the use of digital tools to enhance student learning, Digital tools used to strengthen the relationship with learners, and the pressure experienced by teachers in using some digital tools in their classrooms.

Training in the Use of Digital Tools to Enhance Student Learning

The workshop conducted with the participants equipped them with some necessary skills relevant to mathematics teaching. These skills included the typing of mathematics papers, podcasts, creation of slides for PowerPoint presentations and MP4 videos over their slides, together with the basics on using their laptops. The questionnaires administered were divided into three components that tested their competence, relatedness and autonomy. For competence, the results are displayed in **Figure 2**.

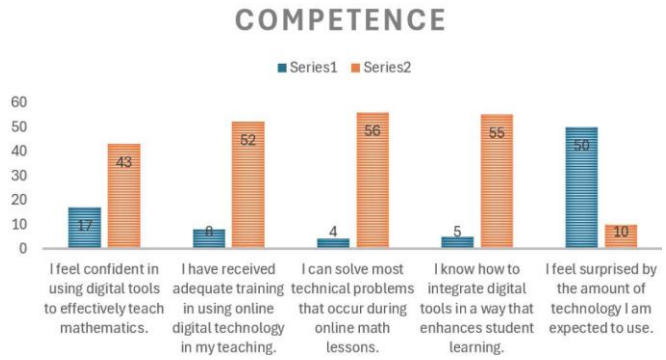

Figure 2. Competence management (Source: Author's own elaboration)

When the participants were asked how confident they were in using digital tools effectively in their classrooms, their responses were:

> P2: I can say I am competent because I have just learnt in the workshop you conducted even to save what I have written; I still need more practice.
>
> P1: I can say that I am excited but far from competent, maybe with time, I'll come right.
>
> P4: Yes, I can confirm my confidence in using many of the digital tools, we used them at the college. Now I can show some of my colleagues on how to use them.
>
> P1: If I can practice, I'll be fine, for now I cannot say I am confident.

This lack of confidence in using digital tools concurs with Faloye and Ajaya (2021); together with Isaac and Winke (2024) who note that the digital divide significantly affects mathematics education in South Africa by exacerbating existing inequalities and limiting access to quality learning resources and modern teaching methods. Only one of the four participants got training in college and was eager to use digital tools in all his mathematics lesson delivery. **Figure 2** also indicates that only 8 out of 60 teachers received adequate training on using digital tools. Moreover, just 4 of those could solve technical problems that occur during their online mathematics lessons while only eight percent of them could integrate digital tools to enhance learning in their lessons. During interviews these were what they said:

> P1: I cannot say I was trained adequately; two days training is not enough when you have to learn various computer skills for the first time.
>
> P2: No, I still need to be trained on how to use PowerPoint. Although I mastered it well during that training, I am not confident to do it on my own. What made me excited was to learn that I could send a document from my computer to my phone. Because now it becomes easy to send to my learners' WhatsApp.
>
> P4: The training was useful in polishing my technology use skills, we did this when I was still studying. Now, I am going to use online digital tools in all my maths lessons.
>
> P3: As for technical problems, it is even hard for me to tell how the problem arose, I am still struggling even to save a document.

This refutes Sahal and Ozdemir (2023) who acknowledge that rural primary schools and mathematics teachers have positive views about using technology and they are willing to use technology classes. A transformed scenario is yet to be realized through workshops that empower teachers with adequate training in using digital tools in their mathematics classrooms. They were also excited to learn that some documents composed on their computers could be shared with their learners on WhatsApp. This adds to the pictures that they took with their cell phones to share with the learners on the same platform.

Digital Tools Used to Strengthen the Relationship With Learners

Digital tools are known to facilitate personalized feedback, active participation, collaborative projects, and frequent communication, allowing teachers to connect with students on a deeper level and build a more supportive and engaging learning environment. In this study it was evident that most participants felt that using digital tools made them to connect with their learners. They mentioned especially that they connect with their learners through WhatsApp and use other digital tools to communicate with their colleagues as well. Their responses in the questionnaire are displayed in **Figure 3**. Data collected revealed that 97% of the participants felt more connected to their learners when using digital tools. In addition 80% of participants confirmed that they could collaborate with other teachers through online platforms, although only 25% of them felt supported by their colleagues when using digital tools. It was surprising to find that only 34% engaged more with their learners during online or tech-supported mathematics lessons. Seventy seven percent of the participants felt isolated when teaching with digital technology. When they were asked how using digital technology affected their relationship with their learners, they said:

> P4: I have the best relationship with my learners especially when using digital tools. Some of them are able to take photos of problems that give them challenges to solve and send them to me on WhatsApp. Sometimes, it could be about lessons

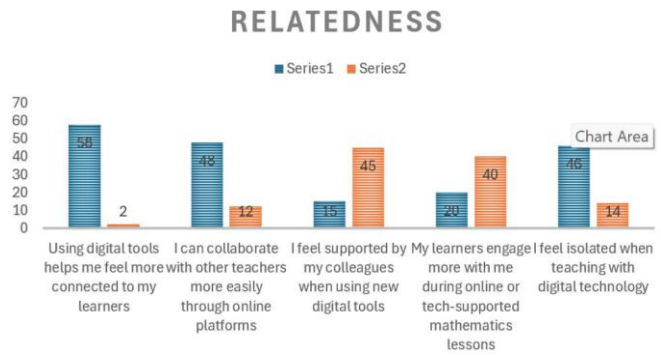

Figure 3. Relatedness (Source: Author's own elaboration)

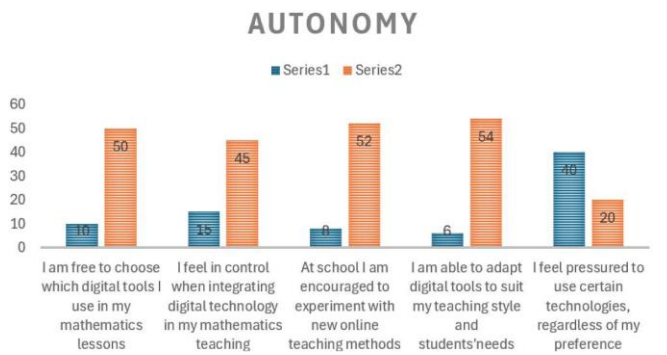

Figure 4. Autonomy (Source: Author's own elaboration)

> that we did in class or as part of their homework. I have also been able to send podcast explanations on how those problems are solved.
>
> P3: I cannot say my relationship has improved because one learner requested me to share one of my lesson presentations that I had done in class for reference, but I found that difficult because I did not know how to do that. But in the morning I requested one of my colleagues to assist me. It is so easy through WhatsApp especially if you do voice over and send the message. Occasionally I am able to interact with a few learners. I then think they share the sums amongst themselves.

When asked if they collaborate easily with their colleagues on online platforms, their responses were:

> P2: Oh yes, it is easy to collaborate with my colleagues in online platforms like WhatsApp using voice notes sometimes, but I barely ask or get support from them to assist with new digital tools. Also, I feel more alone when using digital tools because I was not fully trained.
>
> P3: Yes, I feel isolated when using digital tools, I am not familiar with them, and I do not want to embarrass myself by asking other people.
>
> P1: I got assistance from one of our new colleagues. He taught me how to record MP4 when doing a PowerPoint presentation. This helps me to send to learners in my class especially if I am going to mis my lesson due to meetings during school hours. In that way I feel supported by my colleagues on using digital tools.

This refutes findings by Li et al. (2025) who identify key domains that impact technology integration as the educational environment, teacher professional learning and development, educational challenges, students' technology literacy, and parental and community involvement. Li et al. (2025) regard these factors as collectively necessary for the creation of a supportive ecosystem that facilitates or hinders the effective use of digital technologies in mathematics education. The isolation feeling when using digital technologies was experienced more by those teachers who were shy to ask questions from their colleagues. They therefore felt overwhelmed by the adjustments they had to make for their different mathematics lesson. WhatsApp using voice notes seemed to be the most digital tool used by the participants often. Beyond the training some learnt from their colleagues on how to record MP4 when doing a PowerPoint presentation. This made those participants to feel effective and capable of teaching their lessons effectively. This concurs with Moila (2024) who asserts that teachers' pedagogical competence contributed to how the technology was used in the mathematics teaching and learning environment. expose them to digital resources while giving them feedback that build their confidence in their maths abilities and make the technology to feel like a supportive tool rather than a challenge. Moreover, Earl (2019) adds that SDT informed educational research shows that autonomy, supportive teaching, competence-focused feedback, and inclusive, caring relationships improve learner motivation, engagement and satisfaction.

The Pressure Experienced by Teachers in Using Some Digital Tools in Their Classrooms

From the data collected, only 17% of the participants had the freedom to choose which digital tools they could use in their mathematics lessons. Ironically 25% of the participants felt in control when integrating technology into their mathematics teaching. But just 13% had courage to experiment with new online teaching methods, while only 10% confirmed that they were able to adapt digital tools to suit their teaching styles and learners' needs. Furthermore, 67% of these participants felt pressured to use certain technologies regardless of their preferences (**Figure 4**). When the participants were asked what made them feel pressured during interviews, they said:

> P2: You know, these are modern times, I am one of those who could not do anything on my laptop before this workshop. We are the born before technology group, yes you may ask your colleagues to assist but make sure that you are not left behind.

> P1: Yhoo, the system has changed now, you can no longer rely on chalk and talk, professional development these days demands that keep up with times. Socially as well, one cannot be left behind, you must be seen on WhatsApp at least.
>
> P4: Yes, maybe pressure for all of us, but I think we should be advanced in using digital tools in class, they make my life easier. I suggest mastering of one skill, practice and perfect yourself, use it in class, empower other colleagues and then learn another skill.
>
> P3: Yes, I feel the pressure, because I would love to be able to adapt digital tools that suit my teaching style and meet my learners' needs. I would love support from my school though in terms of trainings like this one from time to time. I have learnt a lot within a short time.

Due to a combination of systemic, institutional, social, and professional factors, most primary school mathematics teachers would feel pressured to use certain technologies in teaching the subject regardless of their preferences. For example, participants in this study are part of a large community of teachers who have been provided with laptops for their professional development. This leads to pressure for them to use that device even when it conflicts with their personal preferences or pedagogical philosophies. A challenging environment for teachers to effectively and willingly adopt new technologies has been created, and this compromises their autonomous status. Factors like inadequate funding, poor digital literacy training, lack of suitable curricula, and the need to align with evolving educational standards contribute to this pressure. This aligns with Li et al. (2025) who highlight that primary school mathematics teachers' preferences for user-friendly, intuitive technologies and their perceptions of ease of use and usefulness are pivotal in shaping their integration practices. Additionally, familiarity with digital tools and alignment with instructional goals was the main objective of the training offered for the teachers to be free when using their laptops. This is agreement with Neufeld (2025) who asserts that the skills learnt in the training led them to independence and a few participants could function without support. There were also participants like P4 who was one of enthusiastic adopters of technology, and this could have made the techno-savvy participants to be afraid of being left behind and thus teachers might have felt the need to conform or risk being seen as outdated.

CONCLUSION

In this article, I have tried to outline how teachers experience mathematics online teaching in rural situated primary schools. In this case study, questionnaires and semi-structured interviews measured autonomy, relatedness and competence to establish these teachers' experiences. Findings revealed that the participants sometimes feel pressured to use certain technologies irrespective of their preferences. The study also revealed that teachers are reluctant to seek help from their peers on equipping them with skills of using digital tools. However, those who had received training adequately in their colleges felt confident and empowered in the workshop and were eager to assist their colleagues. Findings indicate that some teachers prepared MP4 power point video recorded presentations and shared them with their learners using the WhatsApp and were able to type mathematics papers. It is recommended that the teachers also need to learn to video-record all their investigations and experiments in teaching STEM subjects. This could mediate the impact on technology integration caused by the rurality of environment, connectivity challenges, and community involvement. Indeed autonomous, competent and teachers' maintenance of relatedness can foster confidence in online teaching irrespective of the state of their classrooms. When teachers acquire and experience these psychological attributes, they get motivated to engage their learners to learn and this leads to improved performance, innovation and persistence.

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AI statement: The author stated that no AI was used in generating ideas in this article.All analysis and conclusion are the author's version.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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