

Investigation of the challenges in online formative assessment faced by Grade 10 Physical Sciences teachers in South African schools

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ARTICLE INFO

Article history:

Received 02 October 2023

Received in rev. form 20 Nov. 2023

Accepted 27 November 2023

Keywords:

COVID-19, challenges, online formative assessment, Physical Sciences, TPACK

JEL Classification:

I21, I24, I28

ABSTRACT

Formative assessment is crucial for teachers to gauge students' understanding of subject content, and applying formative assessment in an online context is more challenging than in a traditional Physical Sciences classroom. This study examines challenges experienced by Grade 10 Physical Sciences teachers when enacting online formative assessment as per the research question. The empirical investigation adopted a generic qualitative design in which three purposively selected Grade 10 Physical Sciences teachers from three different schools and quintiles within the Tshwane North District in South Africa. Data were collected through individual and focus group interviews. Interviews were video recorded, transcribed and thematically analysed using grounded theory to construct a thematic framework for supporting the study. Technological, pedagogical, and content knowledge (TPACK) was utilised as a theoretical framework underpinning the study to identify challenges experienced by Grade 10 Physical Sciences teachers when enacting online formative assessment. Challenges identified in this study include the enforced utilisation of Annual Teaching Plans, lack of technological knowledge, lack of internet connectivity, and poor digital infrastructure at schools, and in towns and cities in South Africa. The study aims to show that the Department of Basic Education faces the key imperative to provide continuous teacher professional development and concomitant online learning materials that can facilitate meaningful enactment of online formative assessment in various educational settings while policy is needed to ensure that every student has access to data and internet resources.

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Introduction

With the emergence of the Fourth Industrial Revolution, education systems worldwide started a paradigm shift towards incorporating technology in education to better equip learners for the changes that were taking place in industry (Alakrash & Razak, 2021). In November 2002, the National Centre for Education Statistics of the United States of America released a report with suggestions and tools for using technology in elementary and secondary education (Schmitt et al., 2002). Subsequently, South Africa published its first draft white paper on information and communication technology (ICT) in education a year later. The intent was to introduce ICT in education and improve the quality of education throughout the South African education landscape (Department of Education [DoE], 2003). However, the outbreak of the COVID-19 pandemic in March 2020 highlighted how unprepared South Africa's program of education were regarding the use of technology in education nearly 18 years after the proposed integration of ICT in education was promulgated (Ayega, 2020).

In 2022, nearly two years after COVID-19 forced education worldwide to a standstill, many stakeholders in education in South Africa are also researching alternative teaching models because the COVID-19 pandemic did not leave the South African education system unaffected. The state of disaster declared by President Cyril Ramaphosa on 15 March 2020, dictated that schools and other educational institutions had to cease face-to-face education for prolonged periods, and teachers had to find alternative methods to

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<https://doi.org/10.20525/ijrbs.v12i8.2924>

ensure that South African learners had access to education. According to Mahaye (2020) the COVID-19 crisis positioned South Africa and its education system in a new reality and that education would never again find itself in the normal paradigm. In addition, Mahaye (2020) deliberates that education in South Africa experienced a paradigm shift due to the COVID-19 pandemic and that education had to align itself anew with a change in schooling to online and, specifically, blended learning. However, indications were that an online education system could only be successful in a country with developed digital infrastructure and that rural schools in South Africa would not benefit from distance education due to a lack of proper digital infrastructure and the inherent inequalities in the education system (Landa et al., 2021; Mahaye, 2020).

Onyema et al. (2020) mention that during the school closures due to COVID-19, many teachers and learners depended on technology to ensure that learning could continue. Still, the lack of digital infrastructure, poor digital skills, internet access, unavailability and lack of electrical power proved challenging. Consequently, the COVID-19 pandemic emphasized the importance of teachers and learners improving their digital skills. The European Union responded to the academic crisis by advocating quality education for future teachers, ongoing professional development, and the development of teachers' digital skills (Perifanou et al., 2021).

This study presents information that stakeholders and policymakers may use to reinvent education in South Africa and formulate policies to ensure an education system that will weather future pandemics and crises and address teachers' challenges when teaching and assessing online. Furthermore, the study attempted to identify critical areas of development regarding online formative assessment to empower Grade 10 Physical Sciences teachers and prepare them for the digital era.

This paper is organized as follows: following the introduction part, a second part is a literature review with theoretical and empirical studies that shed a light on linkage between theory and practice. The third part introduces the background information on research and methodology. After analysis and findings of the study, authors provide discussions and implications. Finally, this paper concludes with key points, recommendations, future research directions and limitations.

Literature Review

The integration of digital technologies and the internet in education has become increasingly prevalent. However, the digital competency of teachers is crucial for successful online teaching and assessment. The COVID-19 pandemic necessitated a swift transition to online teaching, presenting numerous challenges. Teachers, including those trained in advanced educational technologies, found this transition difficult (Gordy et al., 2021). Haron et al. (2021) identified intrinsic challenges such as lack of skills and knowledge in online teaching, unfamiliarity with online tools, and inadequate preparedness. Additionally, extrinsic challenges included poor internet connectivity in learners' communities and limited access to data, devices, or online education portals.

The Purpose and Importance of Formative Assessment in Education

Formative assessment in Grade 10 Physical Sciences, as mandated by the Department of Basic Education and detailed in the National Curriculum Statement Curriculum and Assessment Policy (CAPS), is crucial in the Further Education and Training (FET) phase. It serves both as an assessment for and of learning, focusing on continuous feedback (Department of Education, 2011). Black & Wiliam (2009) and McManus (2008) describe formative assessment as encompassing both synchronous and asynchronous instructional moments. Bennet (2011) views it as a combination of function and purposefully designed methods. Bartz (2017) and Bulunuz & Bulunuz (2013) emphasize its role in tracking learner progress and understanding their knowledge acquisition. However, its effectiveness can be compromised by teachers' limited appreciation of its value (Alsubaiai, 2021; Ahmedi, 2019; Jawad, 2020). Clark (2012) associates formative assessment with self-regulated learning (SRL), linked to higher academic achievement and learner motivation. The Fourth Industrial Revolution and the integration of ICT have shifted formative assessment towards technology-based methods, though challenges like inadequate technology and less effective online feedback have been identified (Bartz, 2017; Peytcheva-Forsyth & Aleksieva, 2021; Pereira et al., 2021; Perwitasari et al., 2021).

Challenges Experienced by Teachers When Applying Online Formative Assessment

During the COVID-19 pandemic, teachers encountered numerous challenges in conducting online formative assessment, significantly affecting its effectiveness. A central issue was the nature of teacher feedback, essential for enhancing student learning through reflective learner feedback (Pereira et al., 2021; Irons & Elkington, 2021). Asamoah et al. (2022) highlight the importance of both formal and informal feedback but note that feedback during the pandemic was predominantly formal, thus limiting its effectiveness. Jiang and Yu (2021) report a positive change in teachers' motivation to provide formative feedback in remote teaching, yet this shift was marred by challenges such as diminished student interaction. Students often used the online environment to disengage from feedback, leading to teachers feeling a loss of control (Jiang et al., 2021). Mahapatra (2021) identifies the difficulty of providing individual feedback, exacerbated by large class sizes and prolonged periods of online teaching.

The pandemic also saw a reduction in the number of formative assessments, with issues like large class sizes, connectivity problems, lack of student self-discipline, and unpreparedness for online learning being contributing factors (Jiang & Yu, 2021; Pereira et al., 2021). Mirza (2021) points out infrastructural challenges, including inconsistent power supply and poor internet connectivity, coupled with insufficient teacher support. The transition to online teaching required teachers to climb a steep learning curve, underscoring the need for more training in online formative assessment (Pace, 2020; Mitten et al., 2017). The unfamiliarity with digital tools for

online teaching and assessment further complicated the situation (Mahapatra, 2021). Moreover, Pereira et al. (2021) note that interpersonal communication posed a significant challenge in the online formative assessment context. These various challenges collectively impeded the effective implementation of formative assessment in an online educational setting.

Formative Assessment in Science

The effectiveness of formative assessment in Physical Sciences is influenced by teachers' knowledge and understanding of assessment methods. Koulagna (2020) highlights that a lack of knowledge about different types of assessments can affect the kind of assessment applied in class. This is supported by Kaya et al. (2020), who found that teachers often struggle with the practical implementation of formative assessment. In addition, Mngomezulu et al. (2022) argue for the importance of professional development for Physical Sciences teachers to equip them with the necessary knowledge and skills for applying formative assessment effectively.

Online Assessment Practices in Science During COVID-19 Lockdown

Research by DeCoito & Estaiteyeh (2022) on the online teaching and assessment practices of science and STEM teachers in Canada during the COVID-19 lockdown revealed that teachers perceived the online assessment techniques as inauthentic and ineffective. This contrasts with McVey's (2016) findings, which suggest that online environments can support authentic, collaborative, and creative assessments. However, Amasha et al. (2018) indicate that implementing online formative assessment is neither simple nor straightforward.

DeCoito et al. (2022) observed that, despite efforts to use various assessment strategies, teachers tended to favour traditional assessments like quizzes and tests over more creative approaches. This preference was attributed to the emergency remote teaching context, where teachers, lacking prior exposure and training in online teaching and assessment, faced challenges in adapting to the new environment. Additionally, they often lacked the time and skills necessary to develop more authentic and learner-oriented assessments.

Teachers participating in the study reported difficulties in assessing learners on higher cognitive levels and in evaluating practical or lab-based skills. They also found that online feedback was less effective than in-class feedback. Consequently, DeCoito et al. (2022) recommend exploring professional development programmes for both pre-service and in-service teachers, focusing on effective pedagogical practices. They propose the development of a new framework to address online teaching and assessment practices at both national and international levels, acknowledging the need for a structured approach to enhance the effectiveness of online science education.

Online Teaching Challenges During COVID-19

Teachers faced significant challenges in online teaching during the pandemic, including technological, pedagogical, equity, and inclusion issues (Ferri et al., 2020; Stacki et al., 2021). Key issues included unreliable internet services, lack of suitable devices, learner demotivation, and poor digital skills. Ferri et al. (2020) suggest providing affordable digital devices and training to enhance technological proficiency. Collaboration among educational stakeholders is recommended to foster inclusivity and effective online teaching.

Teacher Support and Professional Development in South Africa

Professional teacher development in South Africa involves structured professional learning aimed at improving teaching practices (Darling-Hammond, Hyer, & Gardner, 2017). Ajibade and Bertram (2020) emphasize its critical role in establishing a quality education system. However, they observed a lack of substantial professional support for teachers at the district level. The COVID-19 school closures highlighted the need for effective professional development in online teaching (Liebenberg, 2020).

Theoretical Framework

This study adopted the TPACK framework as a conceptual framework to examine challenges teachers experienced with online formative assessment. The TPACK framework has several benefits when applied, including allowing for reflection on how teachers use technology during a lesson, how teachers contemplate their classroom practices and how teachers integrate technology, pedagogy, and content to benefit the learning process Schmidt et al (2009) explain the seven components of the TPACK-framework as follows:

Technological knowledge (TK) – this refers to the technologies that teachers need to know about when teaching. It includes technologies as mundane as pen and paper to advanced digital technologies such as programs used for online teaching.

Content knowledge (CK) – this depicts the knowledge about the actual subject that is taught.

Pedagogical knowledge (PK) – this refers to the methods teachers apply during the teaching process and the teacher's ability to manage their classrooms, plan for lessons and how students learn.

Pedagogical content knowledge (PCK) – this uses the definition by Shulman (1986) that refers to teachers' knowledge about the teaching process and uses CK and PK to improve teaching practices.

Technological content knowledge (TCK) – this refers to how teachers can use technology to present specific content for teachers to influence how learners understand the content of certain subjects.

Technological pedagogical knowledge (TPK) – this refers to the use of technology in teaching and how the technologies will change teaching methods.

Technological pedagogical content knowledge (TPACK) –this refers to the knowledge teachers need to integrate technology successfully in teaching. Furthermore, TPACK refers to how teachers apply pedagogical methods and technologies to balance the interaction between technology, content, and PK.

Thus, the TPACK framework is a powerful heuristic in examining the TPACK of Physical Sciences teachers. This study sought to answer questions about the use of online formative assessment and the challenges experienced by Physical Sciences teachers by using TPACK as a theoretical framework. Furthermore, TPACK aided in offering solutions to the challenges experienced on the enactment of online formative assessment with a view to strengthen Physical Sciences teachers' TPACK to support and develop the teachers professionally.

Research and Methodology

Research design

This study adopted a generic qualitative research design located within a constructivist interpretivist paradigm. The qualitative research design is relevant as the study sought to understand challenges experienced by Grade 10 Physical Sciences teachers on the enactment of online formative assessment through identification of emerging patterns from the results (van der Walt, 2020).

Sample and Context

For this study, it was necessary distinguish between general, target and accessible populations as specified by Asiamah et al (2017). The first stage was to identify all participants who could potentially be part of the population for the study. For this study, the common attribute required as dictated by the research topic was "Grade 10 Physical Sciences teachers". Therefore, this population would be the "largest possible group that can participate in the qualitative study" and was defined as the general population in this study (Asiamah et al., 2017, p. 1661). Due to time constraints and the study being a minor dissertation, all Grade 10 Physical Sciences teachers falling outside the Tshwane North Educational District were eliminated during the second stage. The third stage was identifying the target population. These were candidates who fit the research criteria and could best divulge their knowledge and experiences under the study's conditions. Stage four involved finalisation of the accessible population. These were candidates willing and able to participate in the study. The accessible population in this study were three participants for the individual structured and focus group interviews in the Tshwane North Educational District. Purposive sampling was used in this study and the participants were chosen based on specific characteristics that suit the study's objective.

Data collection and analysis

An extensive literature review informed the development of interview and focus group questions for investigating challenges faced by Grade 10 Physical Sciences teachers in online formative assessments. Furthermore, the literature review also guided the study's conceptual framework and data collection methods. Data was collected from in-person interviews with three teachers from the Tshwane North Educational District, addressing their experiences, knowledge, and support levels received during the COVID-19 school closures related to online assessments.

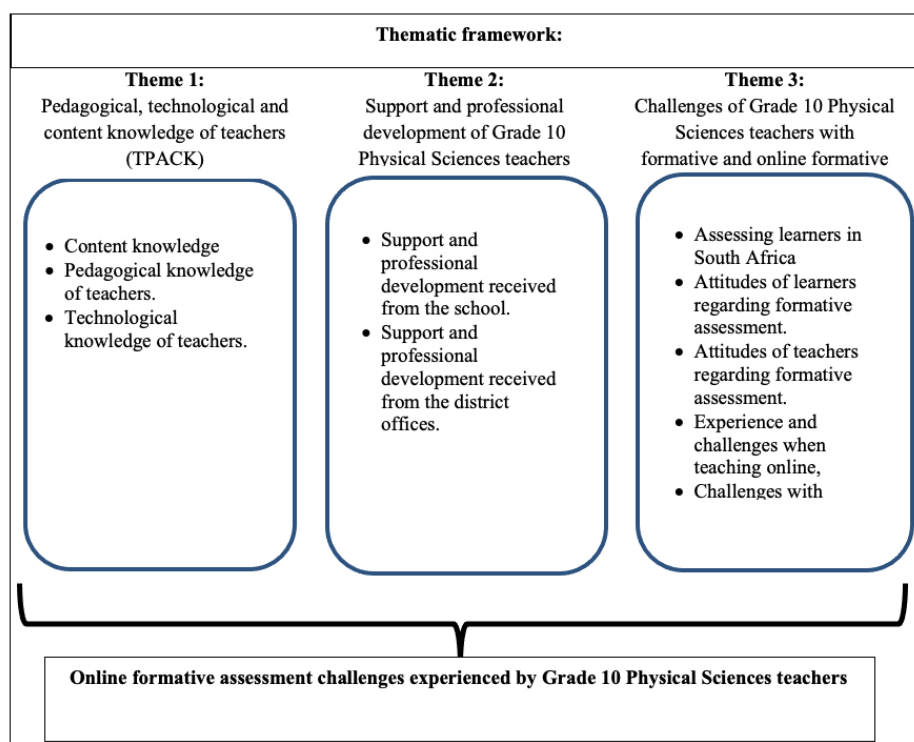
Furthermore, a focus group interview with three Grade 10 Physical Sciences teachers, followed by individual follow-up interviews, were conducted for data triangulation, saturation, and clarification purposes. In addition, all interviews were recorded for authenticity and transcribed using Descript to create intelligent verbatim transcriptions, preserving the meaning of participants' responses concisely.

Reflecting on the researcher's positionality was crucial for this study. Following Kacen & Chaitin (2006), closeness with the participant population was maintained for comfort and openness, balanced with sufficient distance for objective perspective gathering. Furthermore, engaging in reflexivity, the researcher conducted critical self-reflection to ensure the recorded data validly and rigorously reflected participants' views, uninfluenced by the researcher's perspectives on online formative assessment challenges in Physical Sciences.

The study utilized thematic analysis based on grounded theory, employing Atlas.ti for data coding to derive categories and themes. This process involved assigning tags to data segments relevant to the research question, followed by axial coding as described by Neuman (2014). Axial coding, which consolidates and organizes categories into sub-categories, facilitates the elaboration of connections between themes and supports core themes in the qualitative data, akin to providing multiple indicators for variable reliability and measurability (Neuman, 2014)

Selective coding was the final data analysis step, wherein data and codes were reviewed, and primary categories or themes were chosen and organized, with sub-categories or sub-themes adjusted as needed. Consequently, this method facilitated the identification and understanding of key themes in the research data after the full development of all concepts and identification of core ideas, resulting in three main themes as shown in Table 1.

Table 1: Thematic framework created from open coding, axial, and selective coding



The challenges experienced by Grade 10 Physical Sciences teachers when enacting online formative assessment are discussed according to the themes shown in Table 1.

Findings and discussion

Theme 1: Pedagogical, Technological and Content Knowledge

This study defines the theme of teachers' Pedagogical, Technological, and Content Knowledge (TPACK) as the intersection of teaching strategies knowledge, technology integration knowledge in lessons for successful online formative assessment, and subject content knowledge. Based on the TPACK framework by Mishra and Koehler (2006), the study investigated participants' Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) to identify challenges Grade 10 Physical Sciences teachers faced in online formative assessment. It was crucial to explore if challenges in enacting online formative assessments were linked to teachers' CK, PK, TK, or combination of these types of knowledge.

Content knowledge of teachers

All three participants interviewed during the individual interviews were knowledgeable about the content of Grade 10 Physical Sciences as evidenced by their university qualifications. Mr I had a Bachelor of Education in Senior Phase and FET, Mr D had a Bachelor of Education in Physical Sciences and Mr L had a Bachelor of Education in Natural Sciences. The participants confirmed during the focus group interview that their CK was sound by rating their CK as follows: Mr I regarded his CK as "adequate", Mr D described his CK as "quite well" and Mr L indicated that his knowledge of Grade 10 Physical Sciences as "quite good". Thus, taking the participants' qualifications into account as well as the participants' ratings of their Physical Sciences CK during the focus group interview, it became clear that the participants' CK did not pose challenges to meaningful enactment of online formative assessment.

Teachers' pedagogical knowledge

Pedagogical knowledge (PK), as defined by Schmidt et al. (2009), refers to the different teaching methods teachers apply to address the learning needs of various learners. On the other hand, Gathbonton (2008) refers to PK as knowledge of how teachers must teach to ensure that the learning needs of all learners are met. The knowledge of teachers on how to use formative assessment as a teaching strategy successfully forms an integral part of this study. Hence, the PK of teachers on the use of formative assessment as a teaching strategy is investigated in this section. Mr D indicated during the focus group interview that he sees formative assessment as a tool

to inform teachers about what the learners know and understand as well as misconceptions learners hold. Mr D defined formative assessment as follows:

Formative assessment helps a teacher to know where the misconceptions are that a learner would struggle with. Where the strong points are of you as a teacher.

Furthermore, Mr D stated that formative assessment serves the following purpose:

To help learners understand their mistakes. It is not just getting their mark but seeing why they did it wrong.

In addition, Mr I defined formative assessment as follows:

I'd say formative assessment is an ongoing assessment. Assessment that informs teaching.

In addition, Mr I indicated that formative assessment is essential and can inform teaching and learning as the following excerpt illustrates.

I think formative assessment is critical in a teacher's daily life because it informs your decisions about teaching.

Furthermore, Mr L showed an understanding of the positive effects of formative assessment on lesson presentation by the teacher to monitor the progress of learners as reflected in the following excerpt.

Formative assessment brings an understanding between the teachers and the learners as far as presentation is concerned. ... We are trying to administer formative assessment. It's to check the progress of learners.

Participants' views on formative assessment are consistent with the findings of a study conducted by Bulunuz et al (2013) on the effective use of formative assessment as a pedagogical strategy in science teaching and learning. Bartz (2017) concurs that the effective use of formative assessment helps teachers to adapt and change their teaching strategies to support learning and mastery of content. Both Mr I and Mr L reiterated that formative assessment could be of immense value in building the confidence of Physical Sciences learners. In this regard, Mr I stated:

Eventually, the learner was led to think I could achieve 100 per cent for all these concepts because confidence was built.

Mr L stated:

I think it builds some amount of confidence, especially when the learners that are the average student are always a bit better. ...formative assessment brings a lot of grounding regarding confidence, especially regarding small matters and basics in the subject.

The views of Mr I and Mr L on the capacity of formative assessment to build learners' confidence align with the findings of a study conducted by Granberg et al (2021) which demonstrated that formative assessment positively affects learners' perceptions and beliefs about their ability to learn. During the focus group interview, both Mr I and Mr D further exhibited a good understanding of the pedagogical value of formative assessment and the vital role of formative feedback. In support of this observation, Irons and Elkington (2022) maintain that feedback is an essential aspect of formative assessment. Both participants indicated that formative feedback developed learners' metacognition. Mr I stated:

If it is with positive feedback for every little bit of that assessment, I believe it'll make it successful.

Mr D made the following remark about the significance of formative feedback.

Formative feedback helps learners to understand their mistakes. It is not just getting a mark but seeing why they did it wrong.

The evidence gathered from the individual interviews and the focus group interview indicates that the participants in the study had sound PK regarding the purpose and value of formative assessment.

Teachers' technological knowledge

Kurt (2018) defines technological knowledge (TK) as teachers' ability and knowledge of technological resources and how to effectively use technology in a subject area. This definition of TK and the TPACK prompted the researcher to ask the participants to rate their TK during the focus group interview. Mr D indicated that he rated his TK as follows:

I think it was around a six out of 10.

However, Mr D could only mention two online formative assessment tools. In addition, Mr D reckoned that he found online teaching during the COVID-19 lockdown easier than other teachers for the following reason:

I had more technology experience, which made it easier for me to quickly access and got to know different platforms to be used.

However, Mr D subsequently contradicted his previous statement about finding the use of technology easier by saying:

At the same time, you give them a lesson in school and then try to figure out how to make that lesson small enough or put it online and send those links to the children so they can watch the class. ... It was difficult for me because you have all these ideas, but there's no means to be able to, to, even to try and do it.

The statements made by Mr D indicate that his technological knowledge was inadequate when measured against the definition of Kurt (2018). Mr D's knowledge of technological resources is also limited which suggests a lack of technological knowledge.

Mr I rated his technological knowledge at seven out of 10 for the following reason:

I had CAT as a subject at school, and at university, I did something related to ICT in education. During those two courses, my technological knowledge advanced.

However, Mr I lacked knowledge of online formative assessment tools as he could name four tools although more tools are available for online formative assessment. Mr I further indicated that he attempted to use Google Forms during the COVID-19 lockdown but did not attempt to use any other tool. This professional deficiency suggests a minimal knowledge of technologies available when measured against the definition of technological knowledge by Kurt (2018).

In addition, Mr L indicated during the focus group interview that he rated his technological knowledge as good as the following excerpts demonstrates.

Because I'm one person who loves the internet and computers. So, I guess my technological knowledge is good.

However, when asked to name formative assessment tools, Mr L responded:

The one I can remember is Kahoot.

Mr L elaborated:

There were others we were taught about at university, but I haven't explored them yet.

Considering the information gathered from the individual interviews and the focus group interview, it is evident that the TK of all three participants, when measured against the definition by Kurt (2018), is inadequate. Furthermore, when investigating the extent to which the participants received training in the use of technology, it was evident that the participants lacked sufficient training on the use of technological tools. Mr D mentioned during the individual interview:

We had a lot of online classes while I was in university.

Although Mr D had online classes and Zoom meetings, he did not mention any formal training on the use of technology for teaching, either at the university or the school where he taught before the COVID-19 pandemic. He did not mention technological training from the district education office either. Mr I majored in ICT in Education, and he mentioned that he received training from his university. However, the university did not expect him to put the tools to practical use as implied by Mr I's answer to a question regarding the level of experience he has in teaching online. Mr I stated:

They taught us some tools to use online, but practically no.

The "practically" in Mr I's answer refers to the practical use of online tools for teaching. Although Mr I majored in a subject and was supposed to be knowledgeable about technology, he never had any practical experience of the use of technology for online teaching. Furthermore, Mr I mentioned during the individual interview that he had one training session where the district conducted some training in Natural Sciences in online assessment and the different tools that can be used. Mr I stated:

I've only had one experience with Natural Sciences training where the training was based explicitly on online assessment.

When Mr L was asked to elaborate on his training in online teaching, he reported that they received some training while at university as reflected in the following excerpt.

There were others we were taught about at university. ... When I was doing my practical teaching, we tried online teaching.

While the Physical Sciences teachers were exposed to some online tools during their university studies, they did not receive any formal training on the use of ICT tools in education prior to the COVID-19 pandemic. Thus, the participants entered the COVID-19 pandemic without proper training on the use of technological tools for online teaching. The participants' lack of knowledge regarding the online tools and programmes available for online teaching and formative assessment resonates with the findings of a study conducted by Haron et al (2021) which found that challenges such as lack of knowledge and lack of familiarity with online tools were the foremost challenges teachers experienced worldwide during COVID-19 school closures.

Theme 2: Support and professional development of Grade 10 Physical Sciences teachers

This theme focuses on the support and professional development that the participants received from their respective School Management Teams and District offices on online teaching, the use of technology and online formative assessment.

Support and professional development received from the School Management Team

During the interviews with the participants, it became evident that the participants did not receive support from their individual schools for online teaching during COVID-19 school closures. During the individual interviews, two of the participants indicated that they were left to their own devices. Mr D stated:

... from the school's side, we did not receive any support.

In addition, Mr I indicated:

We did not receive any support from the school. You are on your own. You decide what you think you can use and what you can't use.

In addition, the participants mentioned that no training on online teaching and the use of technology was conducted by their various schools or school management teams during the COVID-19 school closures. When Mr D was asked to elaborate on the training received on online teaching from the school where he taught during COVID-19 school closures, he did not mention any training received while Mr L indicated:

....from the school, we don't have much training.

Furthermore, Mr I stated:

The resources are there, but there is no support in getting someone to teach us or give us some training.

The evidence gathered from the interviews pointed to significant challenges experienced by the Physical Sciences teachers when enacting online formative assessment as a result of lack of support and lack of training for online learning from schools.

Support and professional development received from the District Offices

Mr D mentioned during his interview that the only support teachers from his school received from the district during the COVID-19 school closures were data that were exclusively used for memorandum discussions with district officials:

It was always to speak about memos – nothing to help with the technology disadvantage we have at that moment.

Mr D further indicated that there was no support or professional development from the district or Department of Basic Education (DBE) for teachers to empower themselves. The lack of support from the DBE is alarming, since it is evident that there was no effort made regarding the professional development of teachers from the district in which Mr D was teaching. In addition, Mr I mentioned that he attended training sessions on Saturdays, but the purpose was not to support teachers with online teaching but to provide content training.

Teacher training sessions were sometimes conducted on Saturdays and often content based.

Stacki et al (2021) recommends continuous teacher professional development to ensure successful online teaching and learning. During the focus group interview, the participants were asked where they think the support regarding online teaching should come from. Mr L stated:

... from the side of the district as well.

Mr I endorsed the view of Mr L but added that support should come from all the stakeholders involved in education as the following excerpt demonstrates.

From the number one citizen to the level of the learner. Everyone involved in the learners' education needs to play a part.

Mr D added that support should also come from the government:

We are all teaching in government schools which means that the government should support us.

The evidence gathered from the interviews shows that the lack of support from the school, district and national levels and the lack of teacher professional development appear to be challenges hampering successful online teaching and meaningful enactment of online formative assessment by extension.

Challenges Grade 10 Physical Sciences teachers experienced with online formative assessment

Mitten et al (2017) posit that when the necessary technological tools are integrated into the classroom, online formative assessment can be, and teaching facilitated successfully. However, in the case of Mr D, he had limited access to technological tools for use in the application of online formative assessment. Mr D stated:

We did not have any resources to help us with online classes or anything at the school because you could not use the visualisers at that stage because they also could not record.

Furthermore, lack of technological tools for the general population, which was also mentioned by Ferri et al (2020), was identified by Mr D as a challenge hampering meaningful enactment of online formative assessment. Mr D elaborated by saying that students did not have:

...smartphones, or even computers.

In contrast, Mr I and Mr L had better technological tools available for enacting online formative assessment, since both their schools have adequate ICT tools. Mr L stated:

Fortunately, in our case, we do have a sponsor, so we have quite good resources at our school. ... All the learners in my class have phones.

Mr I noted the following:

We are a full ICT school. We receive learner tablets delivered every year by a particular company. Learner tablets are given to the learners. We can use that as a resource. ... The teachers are provided with educator laptops, which we can use for online assessment.

Although learners at Mr I's school receive learner tablets, they are not effectively used by learners during online teaching and learning. Mr I stated:

The biggest challenge is that the learners' tablets are often used for other things than schoolwork.

Mr I and Mr L as well as their learners had technological tools needed for online formative assessment. One of the crucial resources needed for enactment of online formative assessment is the ability of both learners and teachers to connect remotely. From the interviews with the participants, it was evident that poor internet infrastructure and connectivity were challenges facing the participants. According to Mr D, who was living on the school premises during the COVID-19 lockdown, he could access the limited technology available at the school. However, since the internet he had to access for conducting online lessons and online formative assessment could only be accessed via LAN cables, it posed a big challenge because the laptop he used could only access Wi-Fi. Mr D elaborated:

My laptop could not connect to the current internet at school because they still used cables. Hence, for me, using the school's internet resources was challenging.

Mr D pointed out that the learners he taught had challenges accessing online formative assessment tasks:

It is also challenging to do formative assessment in an online situation when students do not have access.

Furthermore, Mr D stated that:

Learners had no access to data, even to access an online test or anything.

During the individual interviews, the participants mentioned the connectivity issue on various occasions when discussing online formative assessment and online teaching. Although Mr D taught in a small town and Mr I and Mr L taught in a township, lack of data impeded active participation of learners when accessing online formative assessment tasks. Mr D stated that:

...students do not have access to data or the internet.

In addition, Mr I mentioned:

...lack of data for learners.

Mr I concurred stating:

The biggest challenge is the internet. ... I think data is the biggest problem currently that we are facing.

The focus group interview supported the statements made by the participants during the individual interviews. Mr I stated that he believes that online formative assessment is preferable to paper-based formative assessment but:

...it is difficult for us, you know, even though we are a full ICT school, our learners do not have access to the internet.

Mr I reiterated that data and Wi-Fi were challenges when enacting online formative assessment. He mentioned the use of Google Forms to create online quizzes and indicated that because the learner tablets needed Wi-Fi to function, they were useless for enacting online formative assessment as the following excerpt indicates.

Only one or two who have data will do that.

In addition, Mr I mentioned that even if they wanted to do online activities at school where there is Wi-Fi available:

...there's only a small part of the school that has Wi-Fi coverage.

As far as teachers and learners are concerned:

...the school also doesn't provide data.

Mr L has not used online formative assessment during distance teaching. He did, however, attempt online formative assessment using Kahoot in class. But even at his school where there is Wi-Fi available, the process was challenging. Mr L indicated that the learners used the small routers at school to access Kahoot, because:

...we have Wi-Fi, but the physics lab is far from the router.

This caused Mr L to have limited use of formative assessment in an online learning environment. The prohibitive cost of data in South Africa was mentioned by Mr D during the focus group interview as a challenge to the enactment of online formative assessment. Mr D mentioned:

One of our biggest problems in conducting online formative assessment is that even I don't always have access to data. Data in South Africa is costly compared to the rest of the world.

Mr D further emphasised that:

...it is one of the most expensive places in the world for data, and students cannot pay that amount of money.

When the participants were questioned about the online tools they used for online formative assessment, Mr D indicated that he had limited access to online tools for enactment of online formative assessment. Initially, Mr D only had access to a free Zoom account which allows only 40 minutes per Zoom meeting when more than one participant sign in:

The problem with Zoom is you need to pay if you want to have a lesson longer than 40 minutes.

Mr D further indicated that the DBE provided Microsoft Teams as an alternative to Zoom. However, the learners were not familiar with Microsoft Teams, and a lack of knowledge about the platform regarding passwords meant that the learners could not access the lessons and online formative assessment tasks as intended. Mr D elaborated saying:

The Teams meetings were difficult because the children couldn't access the Teams. They didn't know how.

Consequently, Mr D resorted to using WhatsApp to communicate and to send content while using Google Forms for online formative assessment activities. In addition, Mr I mentioned that not all teachers and learners have sufficient knowledge of online tools and technology to enact online formative assessment or lessons properly:

Lack of knowledge by the people who are supposed to implement, not just the learners having a lack of knowledge.

Furthermore, Mr I believed that older teachers were not always able to use the technological resources at their disposal:

If we expect them to now go into some assessments online, it's a bit of a challenge for them.

In addition, Mr I posited that learners' technological knowledge and skills pose a challenge to the enactment of online formative assessment:

If we shift to an online situation, the learners do not have basic computer skills. ... most of the learners I am teaching have little computer knowledge.

Learners' poor digital skills and lack of technological knowledge of older teachers, mentioned by Mr I, resonates with the findings of a study conducted by Ferri et al (2020) which identified poor digital skills of learners and technological knowledge of teachers and learners as critical areas for development.

Conclusion

This study examined challenges experience by Grade 10 Physical Sciences teachers when enacting online formative assessment. The findings revealed that the three Grade 10 Physical Sciences teachers who participated in this study had sound pedagogical knowledge and content knowledge of Grade 10 Physical Sciences. The participants also demonstrated a plausible understanding of the pedagogical value of the enactment of formative assessment as a pedagogical strategy to gauge learners' understanding and identify misconceptions to inform teaching and learning. Poor digital skills, prohibitive data costs and lack of support from various school management teams during the COVID-19 school closures remained pervasive challenges. Furthermore, lack of teacher professional development from the district on the utilisation of technological tools hampered meaningful enactment of online formative assessment when teaching Grade 10 Physical Sciences. The teachers expressed fundamental appreciation of the pedagogical value of formative feedback to development learners' metacognition. It is however important to note that the sample size was very small and that the findings are based on the experience of three teachers in a specific subject, thus the findings cannot be generalised. Consequently, to gain a better understanding of the challenges other teachers experience when conducting online formative assessment the scope of the study should be increased considerably.

School management teams and district offices face the key imperative to provide sustainable teacher professional development opportunities on the utilisation of technological tools in partnership with the DBE to strengthen meaningful enactment of online formative assessment at schools. There is a critical need to harness lessons learnt from the COVID-19 pandemic induced sudden transition to online teaching and learning in Physical Sciences. According to the Bill of Rights (1996), everyone in South Africa has a right to basic education. Furthermore, the South African Schools Act (SASA), 1996 (Act 84 of 1996) aims to ensure quality education for all learners in South Africa. Therefore, to give practical expression to the Bill of Rights and the South African Schools Act, the South African government should formulate a policy that would ensure that all learners have unlimited access to the internet and the requisite technological resources at schools.

Based on the evidence gathered from the individual and focus group interviews and the thematic analysis thereof, the study makes the following recommendations:

- i. The digital skills of learners and teachers need to be enhanced to ensure successful online learning and formative assessment.
- ii. School management teams need to be more supportive of teachers and must make sure that teachers are developed professionally as far as their digital competency is concerned.
- iii. School management teams need to invest in technological resources which will make the application of online formative assessment less problematic and challenging.
- iv. School districts and the Department of Basic Education should invest in the professional development of teachers to empower them with the necessary digital skills.
- v. The South African government should focus on discussions with data providers to make data more accessible to learners and teachers.
- vi. Stakeholders must work towards the formulation of policy to ensure data to all learners throughout their school career for formative assessment and learning purposes.

Acknowledgements

The authors acknowledge the contributions of the teachers who participated in the study.

All authors have read and agreed to the published version of the manuscript.

Author Contributions: Conceptualization, C.L.; methodology, C.L.; validation, C.L.; formal analysis, C.L.; investigation, C.L.; resources, C.L.; writing—original draft preparation, C.L.; writing—review and editing, C.L., S. R. and T.D.

Funding: This research was funded by the student herself.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to restrictions.

Conflicts of Interest: The authors declare no conflict of interest.

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