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Introducing Digital Technology in a Rural Classroom: One Teacher's Experience

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Digital technology (DT) does not come with a 'menu' of what teachers can select to transform their instructional practices; it is through use and reflection in/on practice that potential affordances are abstracted. Computer simulation (CS) as DT was explored through auto-ethnography, reflexivity, and action research. The findings of the study revealed that the use of DT when teaching is a sense-making process employed to respond to the contextual and situational demands of the concerned teacher. It is a dynamic and unpredictable situated practice that is focused on the emergent affordances resulting from the interface between technology and pedagogy. The aim is to craft a 'contextualized' technology-driven pedagogy to meet the teaching and learning needs of learners in rural schools. It is a professional learning activity that develops self-knowledge and skills that enrich the knowledge base of the individual teacher. Such knowledge contributes to practice innovation, where DT is adopted and adapted to make learning interesting and inclusive and where it engages learners in constructing their knowledge and developing skills to achieve set learning outcomes. The findings are more descriptive than prescriptive since teaching endeavours cannot be cloned but could assist other teachers who might be interested in using DT in their specific contexts.

Keywords: digital technology, learning, reflection, rural schools, teaching

Introduction

While the talk of the need to integrate digital technology (DT) into teaching and learning resonates and continues to reverberate within the school community, it remains largely rhetorical in rural schools. There is no interest or sustained effort to promote the integration of DT as a pedagogical tool (Botha et al., 2017). There appears to be a lack of digital leadership in rural schools on the part of principals. Much of the existing literature claims that the principal's digital leadership affects technology integration in schools (Greaves et al., 2010; Raman & Thannimalai, 2019). Thus, it is not perplexing and surprising that, despite the existence of three key education policies on information and communication technology (ICT), nothing substantial to reflect the appropriation and embodiment of such policies in teaching and learning has been observed, especially in rural schools (Vandeyar, 2021). The three education policies are the e-Education policy (Department of Education [DoE], 2004), the Guidelines for Teacher Training and Professional

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Development in ICT (Department of Basic Education [DBE], 2007), and the Professional Development Framework for Digital Learning (DBE, 2018). The e-Education policy was crafted to develop public schools as e-schools (by the year 2013), with the primary intention of improving teaching and learning in schools. The Guidelines for Teacher Training and Professional Development in ICT (DBE, 2007) stipulate information and communication technology (ICT) knowledge and skills as a prerequisite to effectively implement the national school-based curriculum, while the Professional Development Framework for Digital Learning (DBE, 2018), is aimed at developing teachers' digital skills, to promote and facilitate learning with ICT tools and digital resources.

Unfortunately, the e-Education policy has either found its way onto school shelves or is still swirling around in the clouds above without being implemented on the ground (Vandeyar, 2021). Unfortunately, the policy has suffered a stillbirth in its implementation in rural schools. Arguably, the lack of digital leadership is hampering visionary planning, excellence in professional practice, the creation of a digital age learning culture, and system improvement (AlAjmi, 2022; International Society for Technology in Education [ISTE], 2014), despite teachers being aware of the benign ability of DT to transform instructional practices. Thus, the environment is inherently unsupportive and disempowering, hampering the adoption and integration of DT into mainstream curricula. This promotes an attitude of recalcitrance, with teachers still stubbornly clinging to dry, replicative traditional teaching practices that have been encultured in schools (Ng'ambi et al., 2014). This is not surprising, as research confirms that there is a general disinterest among some South African teachers in using technology in the classroom (Dlamini, 2018; Mlambo et al., 2020). Resource constraints in rural schools are acknowledged, and their effects on pedagogy have remained detrimental to both learner experiences and outcomes (du Plessis & Letshwene, 2020). Research does, however, offer a glimmer of hope, as there is evidence that digital technology can mitigate some of the challenges brought about by a lack of teaching and learning materials (Wu et al., 2022). Consequently, the question arises of what it means for rural (science) teachers to adopt and adapt DT to transform the current 'aerosol' approach to instruction (where learners are 'sprayed' with information in the hope that it 'sticks' in their minds).

The research question that the larger study reported on here sought to answer is: What were the salient dimensions of the researcher's instructional practice when teaching with computer simulations (CS) in a rural classroom? Inherent in the research question is the importance of rural science teachers' reflection on different issues, such as the influence that DT has on teachers' thinking and actions, the way in which content is transformed in order to be accessible to learners, or how it can be used to engage learners and how they can appropriate the pedagogical affordances (both perceivable and unperceivable) presented by DT. Therefore, the objective is to identify the emergent pedagogical affordances that enable transformative actions that support learning. To that end, teacher agency plays a critical role in noticing, selecting, and utilizing those affordances.

The research question was pertinent when I adopted and integrated CS (for the first time) in my instructional practice in a rural classroom – a unique context

plagued by multifaceted exigent challenges. I believe learning is a process that must be intentionally and purposefully cultivated through opportunities to actively shape the content so that there are no interruptions between how learners access and appropriate the content. A well-connected network of scientific ideas and purposeful understanding will not develop by chance for learners; it has to be pursued actively through the use of appropriate teaching strategies by creating optimal conditions and offering mediating tools in the learning environment (Kokkonen et al., 2022). This aligns with the expectations of the DBE that learning materials should be organised in such a manner that it is coherent and logical to facilitate learner comprehension (DBE, 2011). Therefore, I conducted an inquiry into my professional practice with the intention of using CS to author new professional practices in a context where performative (as opposed to participative) pedagogies are encouraged and promoted. However, I was not fully aware of the severity of learners' deeply rooted familiarity with the conventional mode of teaching. While I believe learners would embrace the opportunity to learn with CS, I found that they needed time to adjust to this new way of learning, given their limited experience with such learning environments. In the broader context of teaching, Russell (2007) warns teachers not to expect too much too soon. The challenge that confronted me was negotiating and accounting for my instructional approach in the broader context of transmissive and performative pedagogies to which my learners were accustomed.

It is a common practice within the circuits in different districts of education departments to set targets for schools to achieve. In a recent study, teachers lamented that the DBE is more concerned with the number of learners passing than with the quality of the passes and does everything in its power to ensure that more learners pass (du Plessis & Letshwene, 2020). The deficiency of such an emphasis reduces teaching to a relatively simple process of teachers enacting particular strategies or teaching moves that will result in a linear progression of improved learner achievement, as measured by high-stakes standardized tests (Warner, 2016). In the circuit where the study was carried out, schools were given a performance average pass rate of 75 percent, which was the average performance required of learners at a given school. Any school performing below this threshold was labelled as underperforming. This is problematic, as the stigma of being labelled thus puts the school in the crosshairs of the DBE and drives them to adopt pedagogies to promote a performative learning culture. This effectively means that the ball is in the teachers' court, and they have to drill learners to pass without effective learning taking place. As for learners, they adopt a 'flight mode,' in which they are only supposed to follow instructions. This 'pass rate syndrome' is turning schools in South Africa into mass-production factories that churn out Matric graduates who meet set requirements/standards. Those who fail to meet the standard can re-write or attend a vocational college. Many, however, give up.

Teaching with Digital Technology in Rural Schools

Digital technology is a term used to refer to all devices and programmes/ applications connected with the use of a computer. There is a paucity of research

on how schools in rural areas integrate such technologies into the mainstream curriculum. Whilst research on rural schools has focussed on teachers' conceptions of teaching and learning (Mafunganyika & Nkambule, 2018), rural teachers' development of PCK for inquiry-based teaching (Shinana et al., 2021), rural teachers' experience of problem-based teaching (Osman & Kriek, 2021), rural teachers' management of discipline (Lunga et al., 2021), learners' experience of learning in rural areas (Moloi et al., 2010), and parental involvement to enhance learner achievement in rural areas (Zenda, 2020), not much has been researched on how teachers in rural ecologies adopt and integrate DT into their practice. Not much is known about how DT is integrated in rural areas to enhance meaningful learning, considering the fact that these contexts are both constrictive and unsupportive (Jita & Munje, 2020). For that reason, it is important to view DT integration by focusing on the effective use of technology to transform how teaching is currently done in rural schools. Arguably, the most effective use of DT transcends beyond using it in fits and starts. It requires fundamental changes in how teaching and learning currently occur in schools. The challenge remains that teachers need to orchestrate instructional approaches that "improve science knowledge and skills; demonstrate the relevance of science to society and the intellectual life of a student; illustrate the changing and uncertain nature of science; develop students' critical thinking skills; improve speaking and writing skills; and motivate students to like science and to want to learn more" (Druger, 2002, p. 148). Hence, more research is needed to explore and understand how DT is transforming rural teachers' thinking and instructional practices to achieve this goal. The integration of DT is not uniform (considering the diverse contexts in which teachers work) and cannot be cloned. This view is rooted in the Deweyan (Dewey, 1938) perspective, which asserts that two or more teachers could live the same experience yet take away different meanings from it. Teachers create different personal meanings from new experiences and interactions (Craig, 2018). Hence, the diverse and idiosyncratic ways rural teachers use DT will help illuminate the finer nuances so as not to miss the enablers and constraints of DT in these contexts where the policy on the integration of DT has remained invisible.

The adoption and integration of DT within these ecologies are both critical and long overdue. In such contexts, science teachers' instructional intentions have remained heavily focused on content coverage and personal feelings and only minimally involve learners (Erdmann et al., 2020). Hence, low levels of learner achievement have been reported, as well as very high dropout rates (Spaull, 2015) resulting from poor teaching and learning experiences, which has not changed significantly over the post-apartheid era (Mlachila & Moeletsi, 2019). Disruptive behaviours, teenage pregnancy, alcohol, and other drug abuse, and the disturbance of classroom activities – all of which affect teaching and learning – have increasingly been observed in schools (Banda & Mweemba, 2016; Marais & Meier, 2010; Mgwangqa & Lawrence, 2008; Reyneke, 2013; Sun & Shek, 2012). Research suggests that teachers in schools with large proportions of learners from disadvantaged backgrounds, which such learners are more likely to attend, are more inclined to use the traditional teaching approaches (Bernstein, 2000). Thus, it is evident that learners in rural schools will lack access to enriching experiences

that are critical for developing their science knowledge and skills. Compared to learners from affluent and resourced districts, the learning needs of the majority of learners from rural schools are not prioritized.

However, some of rural schools' challenges can be mitigated by teachers' collective responsiveness to adopting and integrating DT into instructional practice. The potential of DT affordances to transform the quality of teaching and learning experiences in science classrooms in South Africa (and elsewhere) has been raised extensively in the literature (Gui et al., 2018; Kaur & Singh, 2020; Umugiraneza et al., 2018). Actually, gaps in learning outcomes have been reported between those with access to DT and those without, within and between countries (Dibapile, 2012; Durowoju & Onuka, 2015). From a social justice perspective, the adoption and integration of DT in rural ecologies is viewed as a process aimed at intentionally disrupting the hegemonic practices that contribute to and perpetuate the production of educational and wider social inequalities. This approach distances itself from conventional transmissive approaches by appropriating the pedagogical affordances of technology to engage learners as legitimate participants in an interactive way and provide learning activities they can relate to their personal experiences and prior knowledge, thereby making school science relevant. Hence, how rural teachers orchestrate socially just pedagogic practices, mediated with DT, is worth researching, given the "unforgiving complexity of [such] teaching" (Cochran-Smith, 2003, p. 3). The characterization of rural teachers' use of DT in instructional practice has been overlooked in the literature on science education despite its importance in an era characterized by instructional change reform efforts.

Computer simulation (CS) is one example of a science-specific DT that was used in this study. A CS is a computer-operated application that models the behaviour of scientific phenomena. It abstracts and simplifies those phenomena by focusing on key features to explain and predict behaviour. Importantly, the application illustrates how the dynamic macro-features of phenomena are related to the micro-features. The computer application is thus robust, with interactive affordances that allow teacher–learner engagement with the application. Because of the challenges encountered in rural schools, CS as a resource can be used in science lessons without the fear of breakage or depletion by learners or harm to learners. Most CS are available freely online and can be downloaded and used offline. This is an advantage to schools in rural areas with connectivity problems, and schools do not have budgets for internet connection.

Although many teachers have knowledge and experience of CS, this does not suggest that CS will be integrated successfully into their teaching practice (So & Kim, 2009). Both anecdotal evidence and recent research show that simulation implementation in the science classroom is slow and challenging, especially in rural schools (Bo et al., 2018). These challenges emanate from the complexity of adopting, adapting, and integrating them into instructional practice for specific audiences and contexts (Kriek & Coetzee, 2021).

The characterization of teachers' thinking when using CS is lacking despite its importance in an era where the integration of technology in instructional practice is vital. Research that takes account of the preferences and characteristics

of (rural) teachers and their epistemological beliefs (Kearney et al., 2012) is critical for establishing strong pedagogical practices that will not remain ephemeral. Thus, the lack of a strong research-based approach to teaching and learning with CS has the potential to hinder the adoption and customization of CS within rural pedagogy.

To answer the research question, these three main ideas are employed: (a) self-reflexivity, drawing on the understanding that reflexivity acknowledges that we shape and make meaning about our world from within (Ripamonti et al., 2016) and the conceptualization of reflexivity as reflection with social and scientific foundations that leads to social change (Mora, 2018); (b) autoethnography as a methodology that values personal experiences, which are deemed central to meaning-making and reinterpreting the relationship among actors, events, and contexts (Boje, 2001); and (c) action research as an ethical commitment to improving society (i.e., make it more just), ourselves (that we may become more conscious of our responsibility as members of a democratic society), and ultimately our shared lives (i.e., building community) (Holly & Kasten, 2001).

Reflexivity

Reflexivity and reflection are not synonymous; hence, it is critical to distinguish between the two terms. While there is reflection during reflexivity, the latter is more complex, involving practitioners taking a different ontological position of not just reflecting on issues from an objective distant stance but recognizing reflexively their role as embedded in the flow of events and in constituting social and organizational realities in ways they may be unaware of (Ripamonti et al., 2016). Through reflexivity, practitioners are encouraged to question and recognize their pedagogical responsibilities by becoming more conscious of how their assumptions, beliefs, and actions shape "realities" and create possibilities for moving on in the situations they face.

In the current study, reflexivity was employed because of the need to ground my ideas on the deep understanding of my situation, contexts, and participants as a requirement/obligatory step in engaging in transformative change (Mora, 2018). Importantly, reflexivity enables the practitioner to develop and learn through reasoned reflection on epiphanies – remembered moments perceived to have significantly impacted the trajectory of his/her life (Bochner & Ellis, 1992; Denzin, 1989), and analyzing how others perceive the event. This is critical, considering that these epiphanies reveal the ways in which a person could negotiate 'intense situations' and 'effects that linger long after a crucial incident is supposedly finished' (Bochner, 1984, p. 595).

Autoethnography

Autoethnography is a narrative method of inquiry that priviledges the individual practitioner as s/he seeks to find out about him/herself and his/her relationship with the research topic (Muncey, 2010; Richardson, 2000). In this tradition, the process of writing in a highly personalized style is emphasized as a

form of discovery, drawing on the experiences of the practitioner to extend understanding of a societal phenomenon (Wall, 2006). The autoethnographic approach is often used in first-person action research projects (Sykes & Treleaven, 2009), as an autobiographical genre of research that displays multiple layers of consciousness, connecting the personal to the cultural (Ripamonti et al., 2016).

In the current study, the use of autoethnography was deemed necessary to produce meaningful, accessible, and evocative research grounded in personal experience – research that would sensitize readers to the issues confronting teachers in rural areas, experiences which are usually given lip service and to forms of representation that engender empathy in those teachers. What rural teachers do is often under-recognized in existing literature dealing with the quality of education. Autoethnography acknowledges and accommodates subjectivity, emotionality, and the researcher's influence on research rather than hiding from these matters or assuming they do not exist (Ellis et al., 2010). Practitioners rely on autoethnographic accounts, diaries, or field notes, enabling them to reflect and question their practice. Thus, narrative, discursive, or ethnographic methods are regarded as fruitful ways of generating knowledge.

Action Research

Action research (AR) is situated within a range of narrative research approaches where inquiry is made to address 'issues of concern to individuals and communities in the everyday conduct of their lives' (Reason, 2006, p. 191). Thus, embedded within AR is a commitment to social justice, defined in terms of equal access for all learners to benefit socially and economically from education as a positional good (Lingard, 2005; Reay, 2012). Furthermore, it includes equal access to experiencing the pleasure and enjoyment of learning in coming to understand something that is difficult yet worthwhile, for example, 'discovering what it is to generate intellectual insights or what it is to read critically' (Griffiths, 2012, p. 664). Thus, AR is foregrounded in practices that seek to change cultural practices and discourses that contribute to producing educational and wider social inequalities. AR brings transformation. Inherent within AR is an ethos that seeks to redress and empower the disadvantaged/marginalised through socially just pedagogies. Without this dimension, AR becomes like any other research in which researchers pontificate about a field from the presumed position of 'expert' (Mora, 2018).

In this study, AR was the medium used to initiate a transformation in teaching and learning using DT.

Data Collection

Three types of research reporting underpinning narrative inquiry were used: (a) a descriptive report of a privately constructed self-account in its original narrated form, (b) a recounting of a dialogically generated narrative (or set of

narratives) in story form, and (c) a storied account of an experience constructed from interviews, written reports, observations, and artifacts (Hoshmand, 2005). The data were collected from reflective journals, focus group discussions, and informal communications with colleagues and learners. The credibility of the findings was enhanced by triangulating the data sources. The data were collected over a period of three years, which enabled meta-reflection by the researchers. Meta-reflection is typical of a meta-cognitive mindset; it entails reflecting on a personal reflection from a scholarly point of view. I hoped that by persistent observation and prolonged engagement (Guba & Lincoln, 1989), I would develop a deeper understanding of the use of CS from an 'insider' perspective in practical ways that would render knowledge utilization for interested colleagues and future teachers. Thus, I hoped not only to construct public knowledge of the practice (LaBoskey, 2004) but also contextual knowledge for informing my signature teaching and contributing to professional knowledge about the intricacies of teaching with CS in a rural context.

Data Analysis

The data were analyzed not to develop a theory but rather to illustrate how past experiences can shape future experiences. In Clandinin and Rosicks' (2007) view, 'lived experiences [are] a source of important knowledge and understanding (p. 42). One major way in which experience can be captured and communicated is through the narrative approach. This study is grounded in the perspective that there should be a shift of the research community's attention from propositional knowledge (what teachers should know and do according to experts in the field) to non-propositional knowledge (what teachers know and do, narrated in their terms, using their own voices and word choices) (Craig, 2018). This is important considering the fault lines that exist between theory and practice. Two themes emerged from the data about the salient dimensions of my instructional practice when teaching with CS: (1) seeking a mediated dialogical approach to learning and (2) avoiding putting blinkers on the learners' minds.

Findings

Seeking a Mediated Dialogical Approach to Learning

Seeking a mediated dialogical approach to learning was a frequently recurring theme of my efforts to teach with CS, where the teacher and learners explored and generated ideas and questions together. The simulations created the contextual setting to mobilize and use a mediated dialogue. Thus, a teacher-technology-mediated dialogue was realized, which can be contrasted to a teacher-mediated dialogue from a distributed cognition perspective that the ability to interact meaningfully with tools expands one's mental capacity. We make this distinction because ample research exists on teacher-mediated dialogue (see Kumpulainen &

Rajala, 2017; Resnick et al., 2015; van der Linden & Renshaw, 2004), but less is known about teacher–technology-mediated dialogue. In my reflective journal, I wrote:

> *[CS] are good graphical representations of scientific phenomena in which the teacher can engage learners to verbalise their thoughts, ideas and feelings during a reflective discussion. CS create and stimulate an interactional space for learners and the teacher to talk and think together. I am excited about this, because it eliminates the domination of my voice as the teacher in the class… They provide an environment for exploration of science concepts through dialogue and questioning opportunities.* (Reflective journal, August 2015)

This excerpt brings out the following features of teacher-technology-mediated dialogue: they are *cumulative* (the teacher and learners build on their own and each other's ideas, chaining them into coherent lines of thinking and inquiry), s*upportive* (learners articulate their ideas freely, without the fear of embarrassment over 'wrong' answers, and support each other to reach common understandings), *purposeful* (teachers plan and facilitate dialogic teaching with educational goals in mind), *collective* (teachers and learners address learning tasks together), and *reciprocal* (teachers and learners listen to one another, share ideas and consider alternative viewpoints) (Alexander, 2008). Notably, teacher-technology-mediated dialogue imposes no demarcated limits (learners are not constrained/limited to understand from the perspective of the teacher or textbook author) and supports the development of science language (learners are allowed to express their ideas in their own words).

During the lessons, I found myself assuming a number of roles necessitated by the various actions enabled by the use of CS. My roles shifted between being a facilitator, guide, navigator, and co-learner, encouraging learners to take responsibility for learning and providing opportunities to develop their learning skills. As I traversed between the roles, I had an opportunity to evaluate my thinking and that of the learners and reflect on that. This opportunity determined whether or not I could proceed with the lesson. How these roles interacted, interwoven with self, contributed to the growing tapestry of teaching with digital technology. I was able to reframe my teaching, moving from clashing tales of triumph and tragedy to focusing on how to engage learners in a dialogue so that they could appropriate the epistemic benefits of CS. At the same time, learners had to adjust and assume new learning roles and responsibilities that went beyond listening and taking notes and were encouraged to take control of their learning. The following excerpt was provided by a learner:

> *…he provides both a great mix of listening, speaking and practical learning activities. As a learner you feel pushed to learn and try to gain valuable feedback that helps you to improve. He paces the class just right, so you feel challenged but not overwhelmed. So, in other classes you just read from a textbook but in his classes he asks questions and gets the learners to respond, which are both fun and promote faster learning.* (Wanga)

The approach of adopting a dialogical dimension was both intentionally and driven by three imperatives to help learners build connections. As Gee (2003, p. 73) suggested, '[i]t is the connections or associations that people make among their experiences, that are crucial to learning, thinking, and problem solving'.

- Promoting and Developing Science Language Among Learners

One of the general aims of the DBE's (2011) Curriculum Assessment and Planning Statement (CAPS) (section 1.3d) is to produce learners who are able to communicate effectively using visual, symbolic, and/or language skills in various modes. Related to this aim is the ability to collect, analyze, organize, and critically evaluate information (*ibid*). Thus, there is a need to provide an open space for learners to publicly share and revise ideas without fear that their thinking might be ridiculed or dismissed, thereby stifling learner talk. Talk is evidence of, and a tool for, scientific sense-making and scientific sense-making in itself (Ryu & Sikorski, 2019).

- Engaging Learners as Legitimate Participants in the Learning Process

While not explicitly expressed in the literature on teaching, one of the roles of teachers is to engage learners as legitimate participants. This perspective constrains teachers not to treat learners as 'empty vessels' to be filled with information. Such controlling teaching promotes extrinsic motivation, not intrinsic motivation, which is a crucial aspect of autonomy. Autonomy is the agentic ability to be self-governed with self-directed and determined action, whereas being controlled involves responding under direction or coercion. The learner's comment that '… *you feel pushed to learn and try to gain valuable feedback that helps you to improve*' intimates that engaging learners as legitimate participants develop in them autonomous motivation, which is defined as engaging in an activity for interest and enjoyment, or a sense of personal value and importance (Jiang et al., 2019).

- Valuing Learners' Contributions

The responses by learners, when they observe a phenomenon differ from when they merely imagine the phenomenon. Learners were able to comprehend and communicate the information represented by the CS graphics, and they demonstrated visual literacy skills. Evidence suggests that discussions that are computer-mediated elicit substantive comments from learners, which might require the reshaping, re-accentuation, and reorganisation of ideas (Chi et al., 2017). I noted in my reflective journal:

> *Learners were able to give valid descriptions of the magnetic field around the current-carrying conductors. One learner was able to give a description which I had not anticipated. He said that the field was non-uniform, as evidenced by the fact that the circles were not equidistant, with the field lines near the conductor very close together while those far from the conductor were farther apart. He even suggested that the field was, therefore, stronger near the conductor, while weak far away from the conductor.* (Reflective journal, August 2015)

I valued learner contributions for two epistemic reasons: 1) it was meant to be a process in which 'knowing' was to be developed in individual learners – I

wanted them to develop the 'epistemologies for' rather than the 'epistemologies of' science (Ko & Krist, 2019, p. 980). From a disciplinary perspective, the learners' comments were as valid as those written in the textbook. Their remarks were infused with authentic terms (e.g., non-uniform, equidistant) and expressions not provided by the teacher or the textbook. It was a substantive comment that showed that the learner could interpret the features of the magnetic field – evidence of learning appropriation. 2) by encouraging learners to express themselves, I wanted them to value their personal constructions of meaning, just as they would the textbook. One learner explained why he enjoyed my lessons, '*he is a good communicator and… he likes to hear our opinions…*' (Focus group discussion [FDG], 2015). I took the word 'opinion' to mean their contributions. Evidence shows that most learners unquestioningly accept what appears in the textbook or what the teacher says (Teo, 2016). Such an attitude or mind frame develops when learners are 'filled' with information. Costa et al. (2020) concur that focusing on mastering subject-area knowledge alone is insufficient for capacitating learners with the ability to think critically, demonstrate creativity and imagination, communicate effectively using various media, work collaboratively with others, and self-direct their lifelong learning.

Avoiding Putting Blinkers on the Learners' Minds

In my teaching efforts, I was not preoccupied with dictating notes to learners (which is the custom learning activity in most rural schools). Such an ontological perspective was designed to make the instructional space more inclusive, requiring 'that we see ourselves and our learners as individuals with social identities, backgrounds, prior knowledge, skills, strengths, challenges, needs, subjectivities, and goals' (Loya, 2021, p. 2). These aspects are important to consider when planning, implementing, and assessing our teaching and learners' learning. In my view, handing out prepared notes would be like putting blinkers on the learners' minds, as that would constrain them to understand concepts from the teacher's perspective, thus limiting their locus of cognition. Unsurprisingly, for learners, cramming offered both an escape route and an alternative way to 'temporary understanding'[1] (i.e., convenience learning). Temporary understanding sees the knowledge which learners require for assessment activities for that particular moment, hence it is knowledge for convenience. Learners have no intention or do not expect to use that knowledge beyond the walls of the classroom or after the examination. In fact, the learners intimated that they were highly inclined to reproduce passages of text that they read in their textbooks in the examinations. They would conceivably do the same with the notes they are given. Below are excerpts from learners on the use of CS in their learning:

[1]This term was motivated by an acronym, CPF (cram, pass and forget), which learners in rural schools tend to use. It indicates that learners were not concerned about understanding, only in how to use information/knowledge without expending any mental effort. Such information was solely required for the sake of passing tests/examinations.

> *So, the computer simulations make it easy to understand better as opposed to reading from the textbook. You are able to describe what you have seen in your own words. When you read from a textbook it is easy […] to cram the whole passage that you are reading and reproduce it in the examination.* (Khezwo)
>
> *For example, a learner gets to understand what they are learning without cramming to pass. Also, by using simulations it […] helped us to understand the topics much better, since we got to see what was taught in action. A learner always has the chance to write what he or she understood and not what she crammed.* (Melton)
>
> *… encouraged thinking out of the box and understanding what is taught in-depth rather than cramming, so that in the future if you come across those learning aspects, you'll be able to tackle them even when you are alone. Furthermore, he did not bombard us with a lot of information at once, he aimed to make us all understand one concept at a time, provided us with great examples to work on, because he understood that all learners can learn and succeed, but not in the same way and not in the same day. In addition, I was encouraged to always come to the next lesson prepared, influenced by the fact that he was always prepared, and it was evident that he knew what he was doing.* (Motho)

By not putting blinkers on the learners' minds, they were able to understand better without cramming, thinking out of the box, and coming to the next lesson prepared. However, what was common in the learners' comments was avoiding the practice of cramming – something many learners use to learn, unfortunately. While this finding cannot be generalized, as the learners' comments showed, they are driven to cramming by teaching approaches in which the teacher's voice dominates. Learners would not spend their energy cramming if they were allowed to develop their understanding without science ideas being forced down their throats in the form of prepared notes. Learners need the intellectual stimulus of engaging in critical thinking so that information is not blandly accepted and simply memorized.

Discussion

Despite the lack of teaching and learning resources in schools in rural areas, the small changes, though not revolutionary, brought by the use of digital technology are significant to consider. Thus, teachers wishing to engage learners in meaningful learning realize the possibility of orchestrating transformative instructional practices beyond conventional transmission teaching. Hence, there is a need for concerted efforts on the part of teachers as agents of change and designers who integrate DT in their instructional practices to redress the experience of marginality that learners in rural schools experience due to the various challenges besetting these contexts. However, incorporating DT into instructional practice requires an understanding that extra energy will have to be expended and choices defended because the school culture and climate remain resistant to change or reform teaching practices (Boyle et al., 2013).

Seeking to introduce DT into classroom practice is not an event but a process that teachers engage in, which results in their professional development or growth. In this regard, AR is a mechanism for professional development, bringing about

change/innovation in practice. We propose that school managers encourage teachers to become action researchers. As Arrifin et al. (2018) note, effective teachers in Malaysia are those who carry out research in their classrooms, using the ensuing practical/self-knowledge to address learners' contextual needs. The practical/self-knowledge developed contributes to the knowledge base of teaching and also to organizational knowledge, which can innovate instructional practices (Nonaka et al., 2006; Spender, 1996). Notably lacking in the literature is the mechanism of how such self-knowledge can be tapped into to improve the system.

The affordances presented by digital technology challenge the conventional teacher's role as an exclusive source and definitive authority of knowledge. The teacher and his/her learners must interact with DT to co-construct knowledge through dialogue. Therefore, the use of CS extends beyond it being regarded as an 'add-on' or tool to support 'the way students learn from classroom teachers' (Wang et al., 2014, p. 101) to a tool to 'learn with' (Salomon et al., 1991). Importantly, a precursor to using CS for teaching is for teachers first to be aware of the pedagogical affordances thereof. Such affordances do not come labelled with the technology but are rather abstractions of practice constructed as individual teachers reflect on their use in different contexts. Thus, affordances are teachers' personal constructions by reflexively taking an intentional stance in evaluating themselves and how they interact with CS with their learners. The findings suggest that there is latent potential in using CS to mediate instructional dialogue as an approach to teaching physical sciences, especially in rural contexts.

The features of a mediated dialogic teaching resource and collective and cumulative teaching and learning experiences can potentially improve learning outcomes in rural schools. A critical function of dialogic classroom interaction is communal understanding through collective meaning-making and connection-building (Littleton, 2010). Thus, the focus is not on the instantaneous absorption of knowledge but rather on the use of technology as a 'mediating artefact' (Engeström, 2001, p. 73) in specific activities and their goals which can be seen to contribute to the greater whole. The affordance of using CS as a mediating artefact supports the teacher in making pedagogical decisions or taking actions to engage learners in active learning rather than them being passive listeners. On average, active learning was found to lead to higher examination scores and lower failure rates for all learners compared to learners taught via traditional teaching methods (Freeman et al., 2014).

The primary phenomenon of significance in this study is the shift in the thinking and actions of the teacher brought about by the use of CS in teaching and learning, a shift from focusing on the designed/planned but rather the emerging classroom curriculum. The use of technology stimulated actions where l became intentional and deliberate in my attempt to transform science content in ways accessible and comprehendible to learners. Through the use of CSs, I learned to be reflective, thoughtful, purposeful, and deliberate in my decisions, actions, and questions. CS presented cues and affordances to mitigate the practical dilemmas l faced in trying to carry out purposeful actions in a rural setting. Learning conditions in schools in rural schools are incongruous with meaningful learning. Thus, learners are not in a better position to learn with a sense of belonging and

well-being. Therefore, intentional teaching as an immersion pedagogy creates learning opportunities and discourse so that teachers cognitively engage learners in meaningful and authentic conversations to develop and nurture habits of mind. In increasingly diverse and inclusive classrooms, teachers need professional learning to create mediated spaces where learners with varied social identities and intersectionalities are not constrained but feel welcomed, represented, and supported to learn successfully (Loya, 2021). Hence, predetermining learning experiences is an attempt to provide universal, value-free, rational, objective, and detached ways of teaching and learning (ibid). Such an axiological stance dominates the power and priviledges of the teacher, which could lead to the exclusion of the voices of less-priviledged groups (Alcoff, 2001), where learners are framed as victims needing to be saved.

The use of CS can create interactional learning spaces and engage learners from different backgrounds, with different abilities, and cultural and social dynamics. In this learning space, learners are expected to be not only receivers of knowledge but also co-constructors. Such an epistemological stance requires teachers to shift and dismantle historical perspectives that expect learners merely to be recipients of the information. Whenever content is clearly organized and presented, it is the cooperative responsibility of learners to construct meaning on their own. They need to establish links between interrelated concepts. This network of concepts exhibits the richness in the connectedness of scientific ideas, which enhances meaning-making (Mudadigwa & Msimanga, 2019). However, constructing meaning by accessing isolated content acquired through dictation and rote learning is problematic, as a linear outline is limited in the scope of the relationship of a concept with other scientific concepts. Such knowledge might be useful for recalling low-level tasks but not for conceptual understanding (Taber, 2014). While it is possible that such information can be retrieved, it is difficult for learners to apply rote-learned knowledge to solve problems in new contexts (Novak, 2002). Therefore, cramming only caters to immediate outcomes, not the sustainable acquisition of content knowledge.

The integration of DT in a rural classroom is a complex, recursive, and often rhizomatic process that involves a matrix of interaction between the teacher, learners, content, and the learning environment. Understanding the relationship between the elements in the interaction matrix forms the frame of reference that shapes how our ontology, epistemology, and axiology inform instruction. Our instruction responds to and upholds certain realities, ways of knowing, and values, and the ways in which we facilitate their inclusion in our learning environments (Loya, 2021). In this process, teachers learn by developing and internalizing patterns of professional thinking from opportunities created through teaching and learning. By reflecting on the thinking of their thinking and actions, teachers can make explicit the ways in which they support their learners' learning and engagement. Thus, DT integration involves a paradigm shift, a way of thinking that requires teachers to be conscious, interested, and committed to turning their attention away from content and focusing on the processes of how that content can be transformed to enable meaningful learning through which positive outcomes are attained.

In our view, it is imperative for teachers to understand rural learners' environment and select relevant DT by integrating it in such a way that learners are actively engaged. Teachers must facilitate understanding by being aware of the affordances and the correct use of DT. One way of embarking on this process is to become action researchers, as in this way, teachers reflect on their instructional practices, a critical process in teacher's pedagogical reasoning and action. Through reflection, teachers develop new comprehensions- insights into new ways to orchestrate and support learners' learning and engagement. New comprehensions are the basis on which the abstraction of instructional practices is anchored.

Conclusion

While the lack of teaching and learning resources in rural schools has created pathologies of practice, resulting in collateral damage to learning outcomes, the use of DT has a consequential effect on teachers' instructional practices. Teaching with DT enables a teacher to exercise agency, going beyond the impediments presented by the local context to orchestrate instructional practices that respond to their situational demands. Critical in helping the teacher exercise agency was the autonomy that allowed him to author his signature teaching by reflecting reflexively. In a sense, teaching with DT was a professional learning opportunity that was empowering in that it enabled the teacher to reform his pedagogy in response to the context of teaching, making him a critical agent in bringing change to the field of science education. Teaching with DT was a sense-making process that resulted in pedagogical shifts where the focus moved from content to seeking to establish meaningful and authentic relationships with learners. This was achieved through *a mediated dialogical approach to learning, which involved promoting and developing science language among learners, engaging learners as legitimate participants in the learning process while valuing their contributions.* The interactions presented the teacher with the space/opportunity to assume different roles to address the arising/varying learning needs of learners without putting blinkers on how they understand the content. This is critical since learners in rural schools have long been treated as empty vessels to be filled with information rather than being seen as individuals with agentic roles in the knowledge-creation process. This complex process goes beyond ticking boxes and cannot be expressed easily as a linear function. The use of DT in teaching transforms the process and teacher–learner interactions. The potential of DT to effect this is premised on the teacher developing the knowledge and skills to appropriate such pedagogical affordance. The quality of learning experiences is coterminous with the quality of teacher–learner interactions. For the teacher, teaching with DT is professional learning, a process of seeking new comprehensions/insights on how to appropriate pedagogical affordances to enhance learning, thereby contributing to the ongoing improvement of teachers' knowledge and practice by evolving and extending the boundaries of instructional practice. The way in which DT is implemented in class reflects or draws from distinct epistemological, ontological, and axiological perspectives of teaching.

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