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# Teaching With Technology: A Reflection on the Experience of Teaching With Computer Simulations

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## ABSTRACT

This paper describes the lived experience of one physical science teacher teaching with computer simulations in a rural school. The teacher's goal was to improve the teaching and learning of the physical sciences, which has been identified as a challenge. The study adopted an auto-hermeneutical approach, a method of self-reflection and interpretation, which was deemed appropriate for this study, as it allowed the teachers to critically reflect on their own experiences and interpret the impact of computer simulations on their teaching. The study was also framed by constructivism. Data was gathered from the teacher's reflective journals and focus group discussions with learners. A qualitative data analysis using the Colaizzi method was employed. The outcome revealed that the use of computer simulations is an odyssey, where actions were initiated that pacified teacher-dominated practices. One important transformation to learning was that computer simulations created a learning environment where learners did not passively accept but actively engaged with and believed the scientific ideas being taught. The ultimate goal of the transformation is the meaningful engagement of learners with content in a way that captures the zeitgeist of the 21st century.

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## INTRODUCTION

While there is a burgeoning body of research extolling the educational benefits of integrating computer simulations into teaching, most of this research has been conducted in developed economies. The African context, particularly South Africa, remains a largely uncharted territory. In South Africa, there is a dearth of research on the use of computer simulations in teaching and learning in rural schools. What the literature lacks is the pedagogical perspectives of teachers on how computer simulations are reshaping their instructional practices. The focus has been on teachers, while the research conducted with and by teachers remains on the periphery. This underscores the urgent need for more research in the African context, a call to action for the academic community.[1]

Furthermore, research findings are normally published in academic journals and presented in a manner that is not generally accessible to teachers, further marginalizing them in research that affects their practice. The benefits of using computer simulations for student learning are well-known.[2] However, there

[1] David K Cohen, "Educational Technology and School Organization," in *Technology in Education* (Routledge, 2013), 231–64.
[2] Nico Rutten, Wouter R Van Joolingen, and Jan T Van Der Veen, "The Learning Effects of Computer Simulations in Science Education," *Computers & Education* 58, no. 1 (2012): 136–53; Lara Kathleen Smetana and Randy L Bell, "Computer Simulations to Support Science Instruction and Learning: A Critical Review of the Literature," *International Journal of Science Education* 34, no. 9 (2012): 1337–70.

has not been enough focus on the role of teachers in this process. Teachers are crucial in incorporating computer simulations into the curriculum, and it is important to understand how to make the most of these tools to improve learning outcomes. This author is of the view that integrating digital technology into teaching is not just about using a tool, but it is a transformative force that changes the relationship between the teacher, students, and the learning process itself. Therefore, it's essential to gather individual accounts of how teachers are using computer simulations to understand the unique and varied ways in which these tools are utilized. This complexity adds to the challenge of teaching with computer simulations. As a result, this study aims to provide insight into the experiences of a rural teacher who integrates computer simulations into teaching and learning.

The schools in rural areas are facing significant challenges that are negatively affecting the quality of education.[3] These challenges include a lack of essential resources such as teaching materials, classrooms, furniture, computer and science laboratories, internet access, libraries, water and sanitation facilities, and sports facilities.[4] Additionally, these schools face high levels of violence, discipline issues, theft, and vandalism.[5] These challenges are creating an environment that hinders learning, with many public schools being described as 'cognitive wastelands' where little learning takes place.[6] A report by the Centre for Development and Enterprise (CDE) titled 'The Silent Crisis' highlights the severity of the situation. In the poorest 80% of public schools, students are falling 2.5 years behind the curriculum by the end of Grade 3. Furthermore, the pass rates in subjects like physical sciences are alarmingly low. These issues have a significant impact on the educational development and personal growth of students in these rural areas, and urgent attention is needed to address these challenges. The quality of learning experiences provided to students, especially in rural schools in the field of physical sciences, is not conducive to mental development. National performance in the matriculation examination over the past five years, with the most common performance falling within the 30-39 range, serves as evidence of this.[7] When the national performance is broken down into urban and rural areas, it is evident that students in rural areas have performed poorly compared to their urban counterparts.

Research has shown that teachers in rural schools often experience suboptimal, frustrating, and constrained working conditions.[8] Consequently, these teachers exhibit high levels of burnout and disengagement and may consider leaving the education profession.[9] Teaching is moving away from a focus on growth and purpose (eudaimonic) and becoming more focused on compliance.[10] However, there is emerging research indicating that technology has the potential to alleviate some of the challenges encountered by teachers in resource-constrained contexts. This study does not claim that technology is a cure-all but rather suggests that even small changes brought about by technology can significantly

[3] Blandina Daniel Mazzuki and Sarah Vicent Chiwamba, "Transforming Rural Teaching: Teacher Educators and Pre-Service Teachers' Perspectives on Transformative Curriculum and Pedagogy," *Australian and International Journal of Rural Education* 34, no. 1 (2024): 44–59.

[4] George Du Toit et al., "Randomized Trial of Peanut Consumption in Infants at Risk for Peanut Allergy," *New England Journal of Medicine* 372, no. 9 (2015): 803–13; Servaas Van Der Berg et al., "Identifying Binding Constraints in Education," *Available at SSRN 2906945*, 2016.

[5] Tintswalo Maria Masingi, "The Impact of Ill-Discipline on the Performance of Grade Nine Learners: A Case of Nghonyama High School in Limpopo Province" (2017); Vusumzi Nelson Ncontsa and Almon Shumba, "The Nature, Causes and Effects of School Violence in South African High Schools," *South African Journal of Education* 33, no. 3 (2013): 1–15; Malope Frank Seoka, "Challenges Facing School Governing Bodies in Managing Discipline among Youth at Selected Rural Secondary Schools in Shiluvane Circuit in Limpopo Province" (2019).

[6] Nic Spaull and Elizabeth Pretorius, "Still Falling at the First Hurdle: Examining Early Grade Reading in South Africa," *South African Schooling: The Enigma of Inequality: A Study of the Present Situation and Future Possibilities*, 2019, 147–68.

[7] Department of Basic Education. 2023 Diagnostic Report. Book 1 2023. Retrieved from https://www.education.gov.za/Portals/0/Documents/Reports/Diagnostic%20Reports%202022/Diagnostic%20Report%202023%20

[8] Gugulethu Nkambule and Christina Amsterdam, "The Realities of Educator Support in a South African School District," *South African Journal of Education* 38, no. 1 (2018); Marcina Singh, "Teachers Lived Experiences of Teaching and Learning in a Rural School in the Western Cape," *African Perspectives of Research in Teaching and Learning* 6, no. 3 (2022): 92–106.

[9] Colleen Bernstein and Toni Paige Batchelor, "Qualitative Exploration of Workplace Demands, Resources and Bullying among Teachers in South African Schools: Implications for Individual and Organisational Well-Being," *South African Journal of Education* 42, no. 2 (2022): 1–9; Vasti Marais-Opperman, Sebastiaan Ian Rothmann, and Chrizanne van Eeden, "Stress, Flourishing and Intention to Leave of Teachers: Does Coping Type Matter?," *SA Journal of Industrial Psychology* 47, no. 1 (2021): 1–11; Anuska Rabe-Steynberg, "Exploring High School Teachers' Experiences of Teacher Burnout." (Stellenbosch University, 2021); Sebastiaan Rothmann and Elmari Fouché, "School Principal Support, and Teachers' Work Engagement and Intention to Leave: The Role of Psychological Need Satisfaction," *Psychology of Retention: Theory, Research and Practice*, 2018, 137–56.

[10] Michael F Steger, Bryan J Dik, and Ryan D Duffy, "Measuring Meaningful Work: The Work and Meaning Inventory (WAMI)," *Journal of Career Assessment* 20, no. 3 (2012): 322–37.

transform the way teaching is currently conducted in rural schools. The opportunities presented and generated through technology have the potential to address the lack of adequate and relevant teaching and learning materials that are characteristic of schools in rural areas.

Limited research on the integration of technology into teaching and learning has reported the restricted use of these tools without delving into the practical experiences of teachers using them.[11] Although computer simulations have been suggested to enhance and transform teaching and learning, there is a need for further exploration into the specific ways in which computer simulations transform teaching and learning in specific contexts. This study delves into the author's personal experiences with teaching using digital technology in a rural setting. It is part of a larger study in which the author aims to introduce digital technology into his practice in a context where technology was not previously utilized. This work is not a self-centred pursuit but rather a desire to share valuable insights and lessons to promote good practices, especially considering that the government, through the Department of Basic Education, is distributing tablets to learners in rural schools.

This study seeks to answer the research question: What are the lived experiences of teachers of change resulting from the self-initiated exploration and reflection on personal experiences with integrating computer simulations in their teaching practice that contribute to understanding the benefits of effective implementation?

## LITERATURE REVIEW

### Teaching with computer simulations in schools in rural areas

While there are policies that lay the foundation for integrating digital technology (e.g., the e-Education policy, Guidelines for Teacher Training and Professional Development in ICT, and the Professional Development Framework for Digital Learning their implementation is far from being realized.[12] These policies make provision for the integration of digital technology into school curricula while, at the same time, promoting the development of digitally competent teachers. Globally, there is a thrust toward developing technology-enabled learning spaces in schools.[13] Verdonck et al. define technology-enabled space as one that supports learners' active learning by providing technology.[14] This definition is premised on the view that technology is no longer adscititious to teaching and learning but a relevant curriculum material. Teaching with technology in schools in rural areas should not be optional, considering that learning science in these contexts can be daunting and pose challenges for learners to overcome due to limitations imposed by the lack of teaching and learning materials (TLMs). Providing quality education despite the challenges besetting rural schools is imperative and resonates with Sustainable Development Goal (SDG) number 4. A society's economic and social development depends on its citizens receiving a quality education.

Concerns are raised that the policies either found their way onto school shelves or are still swirling around in the clouds above without being implemented on the ground.[15] There is a disinterest in using digital technology in teaching and learning by teachers, especially in schools in rural areas.[16] Therefore, it raises interest among researchers when teachers integrate digital technology into their practice. While other research has blamed the lack of availability of these devices,[17] there is research that also evidence that even if the teachers have laptops, they are not using computer simulations when teaching physical

[11] K. McKnight, et.al.,"Teaching in a digital age: How educators use technology to improve student learning." *Journal of Research on Technology in Education*, *48*(3), (2016).194-211; P. Mutanga and A. Molotsi, "Investigating the use of mobile communication technology in professional development: a connectivist approach." *South African Computer Journal*, *34*(2), (2022); 76-93.

[12] Department of EducationWhite paper on e-education. Government Gazette (236734). https://www.gov.za/ documents/white-paper-e-education-transforming-learning-and-teaching-through-information-and; Department of Education (DoE), 2004 Guidelines for Teacher Training and Professional Development in ICT. (Pretoria; Printing Works, 2007); Department of Basic Education. (2018). Professional Development Framework for Digital Learning. https://www.education.gov.za/DigitalLearningFrameworkJuly18.aspx

[13] S. Van Horne, et.al. "Using qualitative research to assess teaching and learning in technology-infused TILE classrooms. "*New Directions for Teaching and Learning*, *2014*(137), (2014);17-26.

[14] M. Verdonck, R. Greenaway, A. Kennedy-Behr and E. Askew, "Student experiences of learning in a technology-enabled learning space." *Innovations in Education and Teaching International*, *56*(3), (2019); 270-281.

[15] Thirusellvan Vandeyar, "ICT Policy Appropriation: Teachers as Transformative ICT Agents," *Perspectives in Education* 39, no. 4 (2021): 43–56.

[16] Brian C Hassel and Stephanie Dean, "Technology and Rural Education," *Boise, ID: Rural Opportunities Consortium of Idaho*, 2015.

[17] T. Jita and M. A. O. Akintunde, "Pre-Service Teachers' Competence to Teach Science through ICTs: A Case Study of Lesotho." *The International Journal of Science, Mathematics and Technology Learning*, *28*(1), (2020); 27.

sciences. Denying learners the opportunity to learn with digital tools is a form of social injustice that continues to widen educational inequality. Teachers must add value and build their practices to enhance learners' knowledge and experiences with digital technology. One would argue that it is like expecting a fish to survive outside the water when teachers expect learners to learn without digital technology, especially in this digital age.

There are various digital technologies available to teachers. In this study, the digital technology used was computer simulations. Computer simulations (CS) are emerging cultural tools (ECTs) available to rural teachers to transform how physical science is taught. The use of computer simulations creates opportunities to learn (OTL) for both the teacher and the learners.[18] OTL is a multifaceted concept that includes all the elements necessary to provide students with the best possible conditions for learning. Smetana and Bell conducted a literature review on research focused on the use of computer simulations.[19] Their work, complemented by other researchers, has linked the benefits of using computer simulations with transforming traditional teaching by engaging students minds-on, hands-on and emotions-on.[20] This transformation is achieved through promoting science content knowledge (physics, chemistry, and biology), developing process skills, and facilitating conceptual change. For example, the ability of CS to model scientific phenomena, enabling learners to observe and make interpretations of the resulting graphical representations, is an affordance that makes abstract scientific ideas concrete and accessible to learners without the difficulty of using text.[21] This is advantageous to rural learners, as all of them are English language learners (ELLs).[22] Unlike textbooks, computer simulations present the conditions that result in scientific phenomena. It depicts the inherently dynamic nature of scientific phenomena, an affordance that cannot be demonstrated in textbooks. Thus, learners have found computer simulations to be valuable multi-dimensional (instructive, heuristic, and affective) learning assets and provide epistemic opportunities supporting the meaningful learning of science content. [23]

The benefits of using computer simulations for learning are widely acknowledged, yet there has been limited research on the teaching practices that help foster these benefits. Most research on computer simulations has overlooked the voices of teachers about how they use them. Research on lived experiences is needed to understand the unique and nuanced ways in which computer simulations are transforming teaching and learning in resource-constrained contexts. It is becoming increasingly apparent that technology is shaping teaching and learning in different ways, which include but are not limited to objectives/aims, motivation, roles, and practices of learners and teachers, and assessment.

## THEORETICAL FRAMEWORK

This study is grounded in constructivism as its theoretical framework and aims to thoroughly explore an individual's lived experiences of using computer simulations in a rural context. Constructivism is a theory of teaching and learning that researchers can use to analyse how their personal experiences, interpretation of reality, and application of knowledge impact teaching and learning.[24] The lived experiences of teachers serve as a transactional currency to improve their instructional practice. According to constructivism, individuals construct their understanding of reality through their interactions and experiences in a

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[18] E D Agyei and D D Agyei, "Enhancing Students' Learning of Physics Concepts with Simulation as an Instructional ICT Tool," *European Journal of Interactive Multimedia and Education* 2, no. 2 (2021): e02111; Khaleel AlArabi et al., "Enhancing the Learning of Newton's Second Law of Motion Using Computer Simulations," 2022; Herbert James Banda and Joseph Nzabahimana, "The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement among Malawian Physics Students," *Journal of Science Education and Technology* 32, no. 1 (2023): 127–41; Loyiso C Jita, "Elizabeth Darko Agyei, Thuthukile Jita," *Journal of Baltic Science Education* 18, no. 6 (2019).

[19] Smetana and Bell, "Computer Simulations to Support Science Instruction and Learning: A Critical Review of the Literature."

[20] Agyei and Agyei, "Enhancing Students' Learning of Physics Concepts with Simulation as an Instructional ICT Tool"; Banda and Nzabahimana, "The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement among Malawian Physics Students"; A Gani et al., "Improving Concept Understanding and Motivation of Learners through Phet Simulation Word," in *Journal of Physics: Conference Series*, vol. 1567 (IOP Publishing, 2020), 042013; Rutten, Van Joolingen, and Van Der Veen, "The Learning Effects of Computer Simulations in Science Education."

[21] Banda and Nzabahimana, "The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement among Malawian Physics Students."

[22] M. Tsoka and J. Kriek. "Grade 11 learners' descriptions of their learning with computer simulations in a rural school." *Journal of Educational Studies*,23(2) (2024); 69-89 https://doi.org/10.59915/jes.2024.23.2.4

[23] Tsoka and Kriek. "Grade 11 learners' descriptions of their learning with computer simulations in a rural school."

[24] Tebogo Mogashoa, "Applicability of Constructivist Theory in Qualitative Educational Research," *American International Journal of Contemporary Research* 4, no. 7 (2014): 51–59.

particular context. A lived experience is thus understood as a constructed and subjective reality that does not exist independently of human perception. It is a construction of interrelated events in a stream of time based on the impression of their experiences, cognitive processes, and social interactions. Typically, this is expressed in the words (spoken or written) of the concerned person. The researcher's subjectivity can allow them to accurately understand the world as it truly exists without distorting it.[25] Subjective processes can enhance objective comprehension of the world.[26] Therefore, different individuals may perceive and interpret the same event or phenomenon in varied ways, leading to multiple constructed realities. This broadens the understanding and complexity of a specific phenomenon.

## METHODOLOGY

To make sense of the meaning of the author’s experiences with teaching with computer simulations, the study employed an auto-hermeneutical design. Hermeneutics is a philosophical and methodological approach to understanding and interpreting texts. The term is rooted in the Greek word *hermeneuein*, which means interpreting or translating. According to Gorichanaz, auto-hermeneutics is a systematic approach to exploring and describing the ontological nature of one’s own personal lived experience.[27] Therefore, auto-hermeneutics is an auto-methodology, falling within phenomenology, that seeks to extract meaning or the essence from a lived experience— in this case, the essence of teaching with computer simulations. In auto-phenomenology, the researcher explores their own experiences with the phenomenon within a particular context. Being mindful of one’s practice promotes reflection that enables teachers to create more meaningful and impactful learning experiences for learners to thrive academically, socially, and emotionally, and this gives value to inquiry.

With teachers playing such an important role and being the end users of technology in schools, it is important to learn from their lived experiences the meanings they attach to technology use in the classroom.[28] This approach seeks to understand the essence, defined as the core and fundamental aspects of an individual's life as it is personally encountered, felt, and interpreted. Understanding the essence of a lived experience is crucial, as it helps practitioners gain insights into the complexity of human existence. This answers essential questions relevant to improving teachers’ practice, questions that might fail to strike a chord with other professionals. What does it mean to teach in a resource-constrained context? What does it mean to teach physics? What does it mean to be a rural teacher? How should teachers address the challenges and obstacles they encounter in their practice? How should rural teachers balance effective teaching and lack of resources? The answers to such questions require a qualitative approach to capture, as closely as possible, how a phenomenon was lived by the people who participated.[29] The struggles, pain, emotions, successes, and failures that teachers experience in the course of executing their duties can only be expressed by the affected individuals in a way that resonates with them. An understanding of the complexity of teaching, as expressed in lived experiences, fosters empathy, cultural understanding, and a deeper appreciation of the work teachers do.

### Data Collection

For the study, data was gathered from the researcher's reflective journals and transcripts of three (3) focus group discussions conducted with the learners, one per year in each class. The reflections pertained to the three lessons on Electromagnetism taught during the third term over three years (2015-2017). This research is part of a larger study by the author (2020). One of the objectives was to explicitly state the intention to bring about changes in how science was taught at my school. The researcher made a conscious and proactive effort to address the lack of teaching and learning materials in his school. The researcher

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[25] Carl Ratner, “Subjectivity and Objectivity in Qualitative Methodology,” in *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, vol. 3, 2002.

[26] Ratner, “Subjectivity and Objectivity in Qualitative Methodology.”

[27] Tim Gorichanaz, “Auto-Hermeneutics: A Phenomenological Approach to Information Experience,” *Library & Information Science Research* 39, no. 1 (2017): 1–7.

[28] M. Jantjies and M. Joy, “Lessons learnt from teachers’ perspectives on mobile learning in South Africa with cultural and linguistic constraints.” *South African Journal of Education*, *36*(3) (2016). A. Van den Beemt and I. Diepstraten, (2016). “Teacher perspectives on ICT: A Learning Ecology Approach.” *Computers & Education*, *92*, 161-170.

[29] John W Creswell and Cheryl N Poth, *Qualitative Inquiry and Research Design: Choosing among Five Approaches* (Sage publications, 2016).

used a reflective journal to document my thoughts, feelings, anxieties, and fears, as well as my experiences of success and failure. Therefore, the researcher served as the primary data collection tool in this qualitative phenomenological study. Consequently, the researcher's experiences and beliefs influenced the research process.[30]

## Data Analysis

The Colaizzi Method was chosen as the framework for data analysis.[31] The steps began with familiarisation with the data. This involved reading and reading my reflective journals to become acquainted with the contents. At the same time, another researcher also read through the journal entries to ensure that what was being presented was actually what had been written. This stage presented tensions that had to be navigated, that of a researcher and a practitioner. Taking the eye of a researcher would imply an analytical and objective stance, focusing on data collection and analysis and looking for information to answer the research question, while taking the eye of a practitioner would imply a more subjective and reflective stance, focusing on personal growth and development. Resolving the tensions lay in striking a balance between the two perspectives. How can one effectively integrate the rigor of a researcher with the reflexivity of a practitioner?

The next stage was the identification of significant statements. This involved selecting key statements that capture essential aspects of the experience. A statement becomes significant when it serves a vital role in advancing the plot, contributing to character development, resonating emotionally, embodying central themes, using symbolism, and leaving a lasting impression on the audience. For example, a significant statement was, "*What l have learned is that learners are not able to read as much from diagrams in textbooks as they would with animated 3D diagrams, especially computer simulations.*" The significance was the emphasis on the enhanced learning potential of computer simulations compared to static diagrams in textbooks. In carrying out this stage, assistance was sought from another colleague who was not involved in the study to select what he deemed key statements. The formulation of meanings was constructed from the significant statements identified. The formulation of meanings is a reflective and reflexive process that transforms raw experiences or statements into valuable insights that provide a foundation for informed decision-making and continuous improvement in educational practices. This process, called horizontalization, was carried out independently by each researcher and was compared and cross-checked with two colleagues to ensure the validity of the themes.

The next stage was the consolidation of formulated meanings into theme clusters and themes. This stage involves organizing the derived insights into overarching categories or themes that capture the essence of the reflective process. This process helps identify patterns, connections, and key areas of focus. The result was the development of an exhaustive description of the lived experience.[32]

## Ethical Considerations

As an auto-hermeneutic study, the author was the focus of inquiry, and the other participants who took part in this study were the researcher's learners. The proposed study did not harm the researcher or the learners. Consent was sought and given by parents/guardians to involve their children in this study. No direct mention of learners or other people was made in the study. However, there remained a degree of indirect involvement of critical friends. The author was reflexive and took every precaution not to divulge potentially identifying information about individuals or entities.

## PRESENTATION OF FINDINGS

Thirty-one significant statements were extracted from my reflective journals, and the focus group discussion transcription was analyzed. A sample of these significant statements with their corresponding

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[30] R. D. Britton, *A phenomenological study examining the lived experiences of counseling professionals working with individuals living with HIV* (Doctoral dissertation, The University of Iowa, 2019).

[31] P.F. Colaizzi, Psychological research as a phenomenologist views it. In: Valle, R.S. and King, M., Eds., Existential-Phenomenological Alternatives for Psychology, (Oxford University Press, New York, 1978); 48-71.

[32] J. W. Creswell, *Research Design: Qualitative, Quantitative and Mixed Method Approaches*, 4th ed. (Los Angeles: Sage Publications, 2011); N.K. Denzin, *The Research Act: A Theoretical Introduction to Sociological Methods* (London: Routledge, 2017); Michael Quinn Patton, *Qualitative Research & Evaluation Methods: Integrating Theory and Practice* (Sage publications, 2014).

formulated meanings is included in Table 1. The formulated meanings were then arranged into clusters that coalesced into one overlapping theme.

***Computer simulations pacified the 'vices of traditional pedagogy.'***

Vices of pedagogy refer to negative pedagogical practices that can hinder student learning and development. The opportunities presented by computer simulations created a social, expansive and dynamic space for the teacher to engage learners to participate freely as cognizing beings. The environment created positive social interactions that promoted active participation, exploration, and cognitive engagement of learners. Therefore, there was no suppression of individual expressions by the dominant or commandeering voice of the teacher. It was made clear to the learners that there were no wrong or correct answers. Most of the significant statements referred to the enabled actions, which refer to actions or activities that were facilitated, empowered, or made possible by the computer simulations, which were engaged by the teacher and/or with learners. Inherent in the term enabled is the idea that the affordances of computer simulations act as a potential nudge for action.

**Table 1 Examples of significant statements and corresponding formulated meanings**

| Significant statement | Formulated meaning |
|---|---|
| The computer simulations helped the learners to describe the nature of the magnetic field around the wire. I made the learners observe carefully and describe what they were seeing. Indeed, it helped. | Computer simulations enhance observational skills to develop understanding through active learning. |
| So, it's clear to me that learners will participate in discussions of things they are seeing and not being told. Even in group discussions, learners were making reference to the computer simulations. | Beneficial peer discussions are supported by observable/concrete objects. |
| From the discussions that l had, it is very possible that learners can use computer simulations to explain ideas to their peers. Learners learn a lot from their peers if they are guided. | Computer simulations present learners with opportunities to interact with peers. |
| I was able to elicit a response from the learners that I had not anticipated. One learner said that the field was not uniform since the circles were not equally spaced, 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. | Computer simulations provide fertile ground to stimulate the development/construction of knowledge. |
| Furthermore, the simulation representations really worked to show learners that electric charges (electrons) are responsible for the magnetic field. | Computer simulations support a visual/concise understanding of the phenomenon. |
| I felt that the computer simulations l used to demonstrate the field around a solenoid were a bit difficult to understand because it was moving fast. | There are inherent shortcomings in computer simulations. |

These enabled actions are pivotal elements that define the significant statements pertaining to the transformative experience of utilizing computer simulations in teaching and learning. The actions enabled by computer simulations play a crucial role in promoting pedagogical practices that engender deep learning of content by learners. The responses of the learners during FGDs revealed a feeling of satisfaction with the way they were learning.

> *Learning with computer simulations has been such a help to me because l get to experience a new way of learning by visualizing what l am being taught. Computer simulations take us out of the world of imagining giving us an opportunity to experience ideas in action (FGD 2015, Ramua).*
>
> *What l like about computer simulations is that they play a major role in my understanding of physical sciences. They make me easily visualize science ideas in my mind which is not easy because ideas such as electromagnetism is something we don't know how it occurs or how it works as we don't see them often. In physical sciences, there are many things we (accept) that occur, but we cannot even see them like forces however, computer simulations allow us to see this happening with our naked eyes (FGD 2015, Neo).*

The response from the learners reveals two important changes or transitions in their learning that were brought about by the researcher's approach to teaching using computer simulations. The new way of learning is a transition from imagining to visualizing. This transition from the realm of imagination to experiencing ideas in action connotes the thought of learners being liberated from passive consumption of information and empowering them to actively engage, question, and construct their own knowledge and understanding. The second change involves the transition from accepting (scientific ideas) to believing. It is worth noting the difference between acceptance and belief. Acceptance is an engendered and passive tolerance or accommodation of an idea without necessarily endorsing it or being fully convinced of its truth or validity- a product of dictating notes without meaningful engagement with the content. Belief, on the other hand, involves a cognitive component where conviction is engendered by evidence and reasoning- a product of deep engagement with the content. This transition enhances the relevance and applicability of the content material, enabling learners to see how concepts manifest themselves in practical scenarios. The changes brought about in learning negated the subtle and often unconscious ways in which the researcher might have exercised power and control over my learners through symbolic means.

Incorporating computer simulations into teaching and learning created what the researcher viewed as a learner-centred and interactive learning environment where learners focused on the critical elements/specific features that improved their comprehension of the concepts. This necessitated a shift in the researcher's role from being a transmitter of information to a co-creator of knowledge with their learners. Learners were afforded the freedom to engage with the subject matter from dual perspectives, liberating them from the confines of pre-scripted notes or explanations provided solely by the teacher. The following, except shared by a learner, sheds light on certain social dimensions of the researcher's lived experience that may have eluded awareness, enriching understanding of the essence of the researcher's lived experience.

> *One of the qualities that a good teacher must have is being able to break down information so that the learners can understand, which is what our teacher did when he taught us. He 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, and 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 (Wanga)*

The excerpt reveals the attempts that the researcher made to establish authentic relationships with the learners to engage them in meaningful learning experiences. In this study, the teacher did not dictate notes or, in the words of the learner, *bombard us with a lot of information*, but the learners, through the class discussions, were enabled to explain the concepts using their own terms/words. The forms of symbolic, metaphysical, and physical powers experienced allow *learners to understand what they are learning without cramming to pass. Also, using simulations also 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 (Erna).* For instance, a learner opted for the term 'expanding' when describing the nature of magnetic field lines around a current-carrying conductor. Although the technically accurate term would be 'concentric,' the emphasis was placed on the learner's comprehension of the underlying concept, highlighting the significance of understanding over precise terminology. In this approach, language usage was not dictated solely by the teacher; instead, learners were provided abundant opportunities to articulate their thoughts using words and terms familiar to them. This fostered an environment where learners did not feel compelled to merely repeat the teacher's words or replicate content from textbooks. The emphasis was on empowering learners to express themselves authentically, alleviating the pressure associated with memorizing specific phrases or concepts. There was no attempt to suppress individual expressions or ignore/marginalize certain perspectives brought by learners. The interactive nature of the simulations encouraged collaboration, communication, and a sense of community among learners that freed learners from the thrall of traditional teaching methods that stifle their autonomy and inhibit their potential for self-directed learning, contributing to a more inclusive educational experience.

Under the weight of teacher-centred practices, learners often find themselves confined as prisoners of pedagogy, unable to engage in meaningful learning that goes beyond memorization or cramming of information. In the confines of traditional pedagogy, where the teacher is the knowledge gatekeeper, deciding which information is included or excluded and how and when it is presented, learners are shackled by such practices, limiting their ability to engage with learning in a manner that resonates with their interests and learning styles. Through the use of computer simulations, opportunities were presented for the teacher to interact actively and focus on learners understanding. Thus, learners were not entangled by the vices of traditional pedagogy. Instead, they were actively engaged as cognizing individuals capable of sculpting their own understanding amidst the boundless expanse of possibility. The non-exhaustive actions and novelty representations of computer simulations enabled individual and collaborative exploration and ideation of scientific ideas. The researcher was also presented with opportunities to elicit learner conceptions of science ideas. He was able to test hypotheses and allow learners to express/author their ideas in idiosyncratic ways. Rather than following a predetermined path, the learners had the freedom to experiment, make observations, and draw conclusions based on their own interactions with the simulation.

> *Many times, I had l to replay the simulations when learners wanted to verify something…I was able to elicit a response from the learners that l had not anticipated. One learner said the field was not uniform since the circles were not equally spaced, 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 2016).*

The lesson's direction was not dictated by the researcher's script but rather by the ideas actively constructed by the learners themselves. The teacher provided procedural, metacognitive, and interactive scaffolding, while computer simulations served as dynamic tools that offered contextual support and guidance, allowing the learners to make the steps upon which to build their understanding. Below are the researcher's reflections:

> *The questions l posed were based on the visually stimulating computer simulation. This elicited meaningful responses from learners. They were able to stretch their thinking and responded with what l felt were meaningful contributions. Indeed, good ideas were given by learners (Reflective Journal August 2015).*
>
> *What l did in stopping the simulations helped learners somehow see how the field around each loop in the solenoid combined to form a bigger field. This computer simulation gave me the opportunity to relate the combining of the magnetic fields around loops to the 'principle of superposition,' a concept they had done in grade 10 (Reflective Journal 2016).*

The types of scaffolding were made to match the specific needs and abilities of learners to foster critical thinking skills and help learners develop a deeper understanding of scientific concepts. This sparked the interest and curiosity of the learners. The following excerpt characterizes the learning environment created by using computer simulations.

> *Our teacher always creates a positive environment that enables students to enjoy learning. I enjoy his class; he assists and enables students to achieve their goals. He is a very thoughtful teacher who puts a lot of thought into how he presents the study materials. His lessons are engaging, and useful, and he is very patient with everyone in the class always encouraging students to try harder even though they are failing. He is not only a teacher he gives us future advice and also motivates us to choose the best universities and courses (Roton).*

The materiality of computer simulations, despite their virtual nature, permeated the fabric of learning experiences with tangible opportunities given to learners for exploration and discovery. Thus, the vices of teacher-centered practices, which confine learners within narrow boundaries, stifling their ability to fully explore their learning potential or ignite curiosity within them, were pacified. This is critical considering the evidence that the cognitive development of learners, especially in rural areas, has been impaired by the prevalent use of rigid teacher-centred pedagogy. The World Bank reports that when learners feel *tied to* rigid pedagogy, they may become disengaged from the learning process, leading to apathy, boredom, and decreased motivation to pursue knowledge. Rigid pedagogy can erode the learners' sense of autonomy and agency, as they may feel powerless to shape their learning experiences according to their interests, strengths, and learning preferences.

## DISCUSSION

The use of computer simulations is a cognitive and evolutionary process. In this process, the teacher sought and utilized the capabilities of technology to create opportunities for interaction and engage learners in exploring science ideas. These opportunities involved the teacher eliciting learners' initial ideas, learners expressing their thoughts using familiar terms, and formulating and testing hypotheses. Learners were engaged in the lesson kinesthetically, cognitively, and emotionally.[33] The visuals of computer simulations supported orchestration, which combines gestures and other non-linguistic, multimodal resources with speaking and listening during learning.[34] This significantly contributed to improving the generation of new ideas by learners. Ideation in learners is enhanced when it is mediated by technology as opposed to occurring naturally in traditional-oriented instruction. Thus, with the presence of computer simulations, the responsibility of the teacher was transformed from the traditional mode of content delivery into new modes of delivery, which sought to democratize learning opportunities in spaces that have largely privatised practices.[35]

Regarding the use of computer simulations, the teachers revealed intentional and thoughtful/deliberate behaviours/actions to negate instructional/disciplinary practices that entrench and perpetuate teacher domination, particularly by reinforcing unequal power dynamics and limiting learners' agency, autonomy, and access to knowledge. Control is one of the biggest concerns for teachers, and this might be the reason why they will always adopt teacher-centred approaches. Long et al. have differentiated between agentic and non-agentic teachers. In agreement, the researcher concurs that only agentic teachers have the unique capacity to engage with their environments, identify problems, and find solutions.[36] In this case, the researcher was able to learn to harness the affordances of technology to transform educational practices, fulfilling the requirements of the vocation of teaching as transformation, maintaining purposiveness and continuity, and inspiring learning.

The assessment practices often drive teachers to act as knowledge gatekeepers and teach to the test, controlling the flow of information- determining what is and not to be learned; this suppresses learners' voices and inhibits critical and independent thinking, leading to feelings of disempowerment and

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[33] Silence Chomunorwa, Emely Mashonganyika, and Andrew Marevesa, "Educator Perspectives on the Use of Technology in Schools in Previously Disadvantaged Communities," *South African Computer Journal* 34, no. 2 (2022): 35–49.

[34] Zhu Hua, Li Wei, and Agnieszka Lyons, "Polish Shop (Ping) as Translanguaging Space," *Social Semiotics* 27, no. 4 (2017): 411–33.

[35] Chomunorwa, Mashonganyika, and Marevesa, "Educator Perspectives on the Use of Technology in Schools in Previously Disadvantaged Communities"; John MacBeath, *The Future of the Teaching Profession* (Education International Brussels, 2012).

[36] Caroline Long et al., "Enabling and Constraining Conditions of Professional Teacher Agency: The South African Context," *Contemporary Education Dialogue* 14, no. 1 (2017): 5–21.

marginalization.[37] Such are the conditions of learning in rural schools.[38] At the same time, learners are subjugated and restricted to passive reception of information, and they are virtually prisoners of (traditional)pedagogy. As a result, they are forced to cram together without the need to understand the concepts being taught. From the analysis of the statements from learners, cramming is a counter-action to the vices of traditional pedagogy. It is not their intention, but they are somehow constrained by instructional practices. The teacher has never enjoyed and been satisfied with his lessons as much as when he started teaching with computer simulations. It became the signature of the researcher's instructional practice, even among his colleagues.

## RECOMMENDATIONS

In view of the findings of this study, the following recommendations are suggested. Firstly, science teachers in rural schools need to be encouraged to intentionally make routine use of computer simulations to transform their teaching. The experience of using computer simulations is an odyssey that transforms traditional classrooms, which have become teacher's fiefdoms, into spaces where learners imbibe the zeitgeist of technology-enhanced pedagogy. Secondly, rural science teachers should share good practices in teaching with computer simulations with fellow teachers to motivate them to integrate computer simulation into their instructional practice. Thirdly, school managers and curriculum specialists need to provide opportunities for professional learning to capacitate teachers to seamlessly and effectively integrate computer simulation into the science curriculum.

## CONCLUSION

Lived experience is an important dimension of teacher knowledge that informs practice. Knowledge is a source of learning and development. Some of the knowledge is not apparent to our consciousness, but it can be captured from the narratives of the experiences of our learners. The researcher's lived experiences when teaching with computer simulations have revealed that a classroom is not placelessness and that it has something to say about ourselves and our learners and how learning in the physical sciences is viewed. Classrooms define and shape how people come to know, to be known, participate, and relate with others. These are spaces where teachers establish long-term relationships with learners and where the learners establish lasting/un-lasting memories. The use of computer simulations becomes a mediating cultural tool through which authentic relationships can transform both the teacher and learners ' place-makers. Teachers who build authentic relationships with their learners and pay attention to place will improve their learning, especially in schools in rural areas. The essence of technology-enhanced teaching, where the fusion of technology and human interaction is to create fertile 'mind gardens' where ideas are planted, nurtured, and allowed to grow before being harvested or cultivated further. By harnessing and leveraging the affordances of computer simulations, teachers can create learning environments that contain symbolic, metaphysical, and physical forms of power, presenting opportunities for learners to engage with content in a manner that is both meaningful and effective for them, enhancing retention and comprehension.

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