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The Influence of the Scarcity of Digital Tools on Practical Assessment Tasks in Electrical Technology in Gauteng Province, South Africa

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This paper explores the influence of digital tool scarcity on Practical Assessment Tasks (PATs) in Electrical Technology within the South African education system. It highlights how technologies such as circuit simulation software, computer-aided design (CAD), and e-assessment platforms have transformed the teaching and assessment of practical competencies. Without such tools, the facilitation of Electrical Technology will remain shallow. Using a qualitative approach, 12 Electrical Technology teachers from a single district in Gauteng Province were purposively selected, and classroom observations and face-to-face interviews were conducted. Using the Technological, Pedagogical, and Content Knowledge (TPACK) framework, the findings revealed that a lack of infrastructure impedes the optimal teaching of Electrical Technology concepts. This is exacerbated by the lack of professional teacher development, which leaves teachers not in par with the latest technological trends. The study recommends that schools make the necessary tools for teaching Electrical Technology available and expose teachers to state-of-the-art professional development training relevant to industry needs. The study also recommends that digital tools be effectively integrated into practical assessment, aligned with the Curriculum and Assessment Policy Statement (CAPS) and the Department of Higher Education and Training (DHET) frameworks.

Keywords: Digital tools, Technology integration, Practical Assessment Task, Digital divide, Electrical Technology

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Introduction

Electrical Technology is a practical subject offered in both South African high schools and Technical and Vocational Education and Training (TVET) colleges, focusing on competencies such as circuit construction, installation practices, motor control, and fault-finding. Traditionally, assessment in these areas has been dominated by physical tasks performed in workshops under teacher supervision. However, the Fourth Industrial Revolution (4IR) and the increasing digitalisation of education have brought new tools for teaching and assessing practical skills. The Department of Basic Education (DBE) and Department of Higher Education and Training (DHET) have encouraged the integration of digital resources into technical subjects to prepare learners for an evolving industry (DBE, 2021). Digital tools—such as Circuit Wizard, Multisim, Tinkercad Circuits, and AutoCAD Electrical—allow learners to design, simulate, and test circuits virtually before implementation. However, the Electrical Technology teachers in the study setting still find it hard to integrate digital tools in the administration of the Practical Assessment Task (PAT). The COVID-19 pandemic further accelerated this transition by demonstrating the importance of online and blended learning approaches (Mtsweni, 2021). With that said, many schools in the education district of the country's capital city, Pretoria, lack digital tools and face a digital divide, making it difficult to teach the subject; hence, this paper.

This paper analyses the impact of digital tools on PATs in Electrical Technology in South Africa, examining both their transformative potential and the barriers that must be addressed. The digital divide, characterised by disparities in access to and use of technology, presents a significant challenge in education, as espoused by Afzal, Khan, Daud, Ahmad, & Butt (2023). This means learners exit the education system with shallow content knowledge (CK), which eventually contributes to the country's rising joblessness (Statistics South Africa, 2023). The main objective of this study was to explore the influence of the scarcity of digital tools in the Electrical Technology subject and how this scarcity affects and contributes to the ever-increasing skills shortage in the country. The main aim of a PAT is to enhance learners' critical skills, enabling them to plan, select tools and software, and make a prototype; these are the same processes practised in industry. Therefore, should a learner fail to develop critical and planning skills, the making of a prototype is not possible, and, as such, the absorption into either tertiary institutions or industries becomes impossible. Some of these critical skills are digital skills, which are mainly involved in Electrical Technology, and the next section unpacks those under the literature review.

Literature Review

Digitalisation and South African Technical Education

According to Kanyemba and Hofisi (2025), technological advancements enabled by the Fourth Industrial Revolution are increasingly making ICTs integral to both basic and higher education. Literature points to several benefits of integrating digital technology into teaching and learning (Amin, 2016). Higher education institutions and students should keep pace with the rapid pace of ICT innovation, paying particular attention to digital media. Globally, digital media and

communication have thus become part of the study and delivery of knowledge. Despite the uncertainty about the impact of the 4IR transformations on society, nearly every aspect of life, including education, is likely to undergo rapid and intense change. Thus, incorporating ICTs into the teaching and learning functions of education institutions, which are hubs for skill development (Arifiati et al., 2020), is important to ensure anticipation and preparedness for current and future challenges. Hence, the OECD (2019) states that institutions of learning should move from reactive to proactive policymaking for service delivery by anticipating citizens' needs before they request services. According to Bagarukayo and Kalema (2018), one of the OECD's key recommendations is, therefore, the establishment of integrated service delivery methods that ensure the accessibility of services and information across multiple channels and methods. As digital technology has become more accessible in South Africa, it is necessary to incorporate it into the effective running of all higher learning institutions. However, Yasak and Alias (2015) argue that most studies on ICT applications in TVET are primarily theory-based and lack substantial empirical evidence. According to Baguma (2018), although numerous studies have been carried out on the application of ICT in universities, Bates (2018) notes that there is limited literature on the application of ICT in TVET colleges and on the administration of PAT in technical subjects. This avenue still requires research attention if digital technologies are to bring benefits equally to practical work, especially in the Electrical Technology subject.

In South Africa, the integration of digital tools into technical education aligns with the White Paper for Post-School Education and Training (DHET, 2013), which emphasises technology-enhanced learning as a strategy to improve access and quality. The policy document (Curriculum and Assessment Policy Statement, CAPS) for Electrical Technology (Grades 10–12) also recognises the importance of ICT integration for supporting both theoretical and practical competencies (DBE, 2011). This was even made when the Gauteng province rolled out laptops and tablets to learners in 2013, in an attempt to reduce paper use in the classroom and provide learners with learning pathways that speak to them, since they are digital natives, born and bred in a rapidly changing technological environment. However, the Electrical Technology teachers still reel from the effects of the digital dive on how they teach their subject's concepts.

Studies in South African TVET contexts indicate that digital tools enhance engagement and learning outcomes in technical subjects. For example, Mavhungu and Tlale (2022) found that simulation-based instruction in Electrical Engineering at a Limpopo TVET college improved student understanding of Ohm’s Law and circuit troubleshooting. Similarly, Khumalo (2020) reported that learners exposed to circuit simulations developed stronger conceptual frameworks before conducting physical wiring tasks. This could then make these learners more marketable, as the industry today is highly digitised and needs graduates who can join and hit the ground running. By using simulation software, learners visualise invisible concepts such as current flow and fault conditions. Studies at TVET colleges show that students who engage with simulations before workshop tasks perform better at troubleshooting and project assembly (Mavhungu & Tlale, 2022).

However, without digital tools, learners cannot simulate real-life situations in the electrical industry. Various studies have explored the use of simulations and digital media in electrical or physics-related education. Mustaqim, Opetu, Sibuea, Siagian, and Junaidi (2022) compared Livewire and Proteus simulation media in a problem-based learning setting for Basic Electricity & Electronics. They found that students using Livewire attained significantly higher post-test scores than those using Proteus, especially in conceptual understanding of DC circuit analysis. In Morocco, a study integrating an "evolution of electrical systems" simulator into electricity lessons found increased motivation, participation, and better academic performance among secondary school students compared with conventional teaching (Yakkou et al, 2024)**.** Another Moroccan study focusing on the acquisition of electrical concepts (e.g., diode-bridge rectifier) showed that computer simulations (using PSPICE) helped high school students better understand electrical phenomena and increased their satisfaction with the learning experience (Yakkou et al, 2024).

In Thailand during COVID-19, the use of simulation labs for direct current circuits increased students' understanding, engagement, and lab skills despite physical restrictions. (openjournals.library.sydney.edu.au). Studies also report increases in teacher self-efficacy when integrating simulation-based learning; for example, rural South African science teachers showed varying levels of self-efficacy in their use of simulations. Given this, the technical schools in the district where this study was conducted appear to be struggling to facilitate Electrical Technology PAT. Digital tools enable teachers to assess the accuracy of circuit designs before physical implementation. Software such as Multisim and Tinkercad Circuits provides real-time voltage and current readings, enhancing the objectivity of assessments. Learners can verify their circuits virtually, reducing common wiring errors and component damage during practical exams (Khumalo, 2020). However, with the current challenges in the country, where the electricity supply is unstable, it is difficult to use the tools or software needed to teach Electrical Technology PAT efficiently. Electrical workshops in public schools often face resource shortages and safety risks due to limited consumables and supervision. Virtual simulations allow learners to experiment safely and repeatedly without risking electrical hazards or costly equipment damage (DBE, 2021). This is particularly beneficial in rural schools, including the district where the study was conducted, where access to components is limited. Digital assessment systems, such as Moodle, Google Classroom, and SA-SAMS, have been adopted by several schools and colleges to manage practical submissions and track progress. Teachers can provide formative feedback instantly, helping learners correct errors before final assessments (DBE, 2021). However, SA-SAMS is the most commonly used software in schools, primarily by administrative staff to capture and process learners' marks. It does not serve any significant purpose in the instructional practices of the Electrical Technology subject.

Despite notable progress, the Ministry of Education has embarked on teachers' professional development through workshops and training, several challenges continue to hinder the widespread use of digital tools in practical assessment. These include, among others, Infrastructure Inequality, where many schools lack computers, stable internet access, and up-

to-date software licenses (Khumalo, 2020). Some schools' experiences have highlighted challenges related to teacher Digital Competence. According to a study conducted by the DBE (2021), the audit revealed that fewer than half of Electrical Technology teachers felt confident in using digital assessment tools effectively. These were the responses of teachers who attended the Department of Education's top-up training in Electrical Technology. However, these top-up training sessions provide better resources during these sessions, which (equipment) is not available in schools. Schools often cry foul over issues like the Cost of Implementation, where Commercial simulation software, other digital tools, and CAD programs are expensive for public institutions.

Theoretical Framework

The use of digital tools in practical assessment is supported by constructivist learning theory, which posits that learners construct understanding through active engagement and experimentation. Simulations and virtual labs provide a safe, iterative environment for learners to test hypotheses and receive immediate feedback (Mavhungu & Tlale, 2022; Vygotsky, 1978). Although this study did not necessarily focus on learners, the way they interacted with the practical content proved useful. The Technological Pedagogical Content Knowledge (TPACK) framework further underscores the need for teachers to effectively integrate content, pedagogy, and technology when designing assessments (Mishra & Koehler, 2006)**.** In Electrical Technology, this means blending physical and digital practicals to ensure that both conceptual and psychomotor skills are assessed fairly. The concept of CK was important in the study because the researchers needed to verify, based on the literature, how much content teachers master. This was coupled with the instructional tools (PK), which are mainly teaching methods used by teachers to facilitate PAT in the Electrical Technology subject. According to Shulman (1987)**,** when one has a strong CK and a weaker or irrelevant PK, one's PCK is compromised. This is so with the TPACK notion, where for one to demonstrate a good TPACK, both the CK, PK, TK, and TCK need to be on point. According to Mishra and Kohler (2006), TCK is the demonstration of the mastery of teaching with digital tools. So, in this study, the teachers' CK, PK, and TCK were observed to determine whether they are combined effectively, identify gaps in the teaching of a PAT, and determine whether teachers struggle to demonstrate all these concepts. Below is the TPACK model that underpinned the study:

TPACK is a framework that introduces the relationships and complexities among the three basic components of knowledge (technology, pedagogy, and content) (Koehler & Mishra, 2008; Mishra & Koehler, 2006). At the intersection of these three knowledge types lies an intuitive understanding of teaching content, along with appropriate pedagogical methods and technologies. The TPACK framework includes seven components (see Figure 1). They are defined as:

1. Technology knowledge (TK): Technology knowledge refers to the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software programs.

This concept was used to assess teachers' level of knowledge of any technology at their disposal when preparing a PAT.

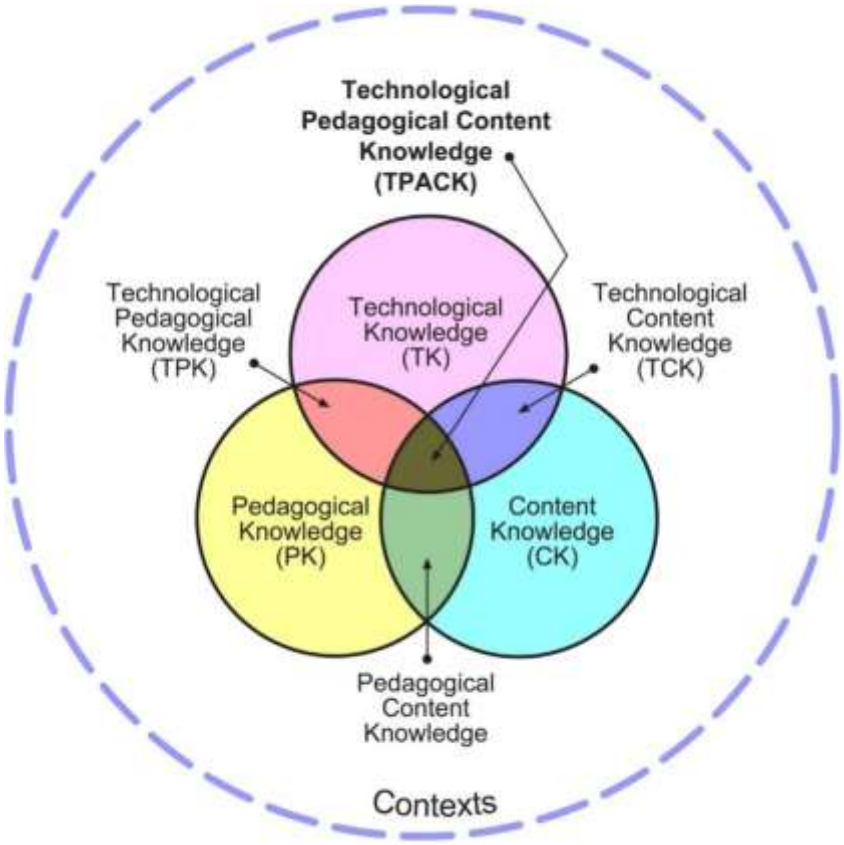


Figure 1

The TPACK Model (Mishra & Kohler, 2006)

2. Content knowledge (CK): Content knowledge is the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006). Teachers must know the content they will teach and how the nature of knowledge differs across content areas. This was checked by observing teachers on the extent to which they demonstrate their mastery of Electrical Technology content.

3. Pedagogical knowledge (PK): Pedagogical knowledge refers to the methods and processes of teaching and includes knowledge in classroom management, assessment, lesson plan development, and student learning. This was verified by checking how Electrical Technology teachers plan their assessments with the fewest tools and equipment they have.

4. Pedagogical content knowledge (PCK): Pedagogical content knowledge refers to the content knowledge that deals with the teaching process (Shulman, 1986). Pedagogical content knowledge differs across content areas, as it blends content and pedagogy to develop better teaching practices.

5. Technological content knowledge (TCK): Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests

that teachers understand that, by using a specific technology, they can change the way learners practice and understand concepts in a specific content area.

6. Technological pedagogical knowledge (TPK): Technological pedagogical knowledge refers to the knowledge of how various technologies can be used in teaching, and to understanding that using technology may change the way teachers teach.

7. Technological pedagogical content knowledge (TPACK): Technological pedagogical content knowledge refers to the knowledge required by teachers for integrating technology into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay among the three basic components of knowledge (CK, PK, TK) through their teaching, using appropriate pedagogical methods and technologies.

Methodology

The research objective is to investigate the influence of the scarcity of digital tools on the administration of the PAT in the Electrical Technology subject in the Gauteng Province, South Africa. The study aims to provide insights to inform strategies and interventions to address the digital divide in PAT, enabling a competitive, skilled learner ready for the world of work. A purposively selected sample of 12 teachers from 6 technical schools in the same district (2 teachers per school) was used in the study. It must be noted that none of the selected teachers had industry experience; they only had a teacher's qualification from the university. A qualitative approach was employed. According to Creswell and Clark (2018), purposeful sampling enables researchers to select individuals based on their familiarity with the topic under study. The reason for adopting a qualitative approach was that the study relied on teachers' experiences in administering PAT in a digitally challenged classroom (Creswell, 2012). According to Ravitch and Carl (2016), qualitative research is, at its core, about viewing, understanding, and engaging with people as having expertise, broadly and specifically, concerning their own experience. Classroom (workshop) observations and face-to-face interviews with Electrical Technology teachers were used to collect data. The use of face-to-face interviews and classroom observations was driven by the study's aim, which required an in-depth understanding of the phenomenon. The instruments were drafted with support from the literature and the study's framework. Ethical clearance for the study was first sought from the Gauteng education district, where the study was conducted, and later from the higher education institution where the first author was a student. The clearance number for the study is **Ref #: REC2024=06=005-HUM**. To ensure that the data were valid and reliable, issues of trustworthiness were addressed. At first, to ensure the data were valid, a senior researcher was roped in to check the instrument. After the data were collected and before reporting, the participants were visited to verify with them what the study intended to report, which ensured that the data were reliable. According to Saunders et al. (2018), 10-12 interviews are sufficient to reach saturation. In broad terms, saturation is used in qualitative research as a criterion for discontinuing data collection and/or analysis (Saunders et al., 2018). In their original treatise on grounded theory, Brackett (2024) defines saturation as follows: the criterion for deciding when to stop sampling the distinct groups pertinent to a category is the category's theoretical

saturation (see Saunders et al., 2018). An interpretive paradigm was used to make sense of the data during analysis. Data was analysed using themes that emerged from the findings. For classroom observations, the critical concepts from the TPACK framework were used to develop themes, whereas interview themes emerged from the teachers' responses. The teachers were given codes: T1 for teacher 1 and T2 for teacher 2. Information letters were given to teachers after permission to conduct the study in schools was sought. The information letters outlined the teachers' rights, including the right to withdraw at any time should they choose to do so.

Results

Classroom/ workshop observations

The workshop observation of the study sought to verify the instructional practices of the Electrical Technology teachers in a digitally constrained environment. There was no specific topic the study aimed for because a PAT is a national task that can encompass many aspects, ranging from critical thinking assessment to measuring, researching, and drawing. The concepts observed were used as themes, as indicated below, and were subsequently followed by sub-themes that emerged. Practical lessons lasted almost 1 hour at each school, and only 1 lesson per teacher was observed.

Theme 1: Content knowledge (CK)

Sub-theme: Demonstration of good subject knowledge

During the observation, the researchers needed to determine whether the Electrical Technology teachers were sufficiently knowledgeable to teach the subject. This was supported by the definitions of CK provided by Shulman (1987) and Mishra and Kohler (2006). All the teachers demonstrated mastery of the content, as evidenced by their qualifications. All twelve teachers were qualified specialists in Electrical Technology, and the majority held a Bachelor of Education in Electrical Technology. However, none of them had industry experience, meaning that whatever content they possessed could be deemed 'textbook'.

Theme 2: Technological Knowledge (TK)

Sub-theme: Lack of proper digital tools

The teachers demonstrated a narrow and shallow knowledge of technology (TK). Those who used technology to teach only went as far as using a laptop and a data projector. For example, in Teacher 1 (T1), he used a USB desktop in his class to project step-by-step instructions for learners to perform a PAT. T3 played a YouTube clip showing the domestic installation by another presenter. This did not allow for in-depth teaching and learning because what learners are exposed to in industry goes way deeper than what was demonstrated. T6 had an old Television that still used old VHS cassettes. Despite the device being old, the content was relevant at the start, which prepared learners to begin a PAT. However, for preparation for tertiary education and industry exposure, the use of a Television is way outdated. T7 and T8 used a smart board, which they managed to operate, but the learning content proved shallow. The reference to shallow learning content was demonstrated by how basic they were when using

the smart board, even when the topic demanded more creativity, which the smart board could have assisted.

Theme 3: Technological Content Knowledge (TCK)

Sub-theme: Shallow demonstration of knowledge of technology tools

Technological content knowledge refers to the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that by using a specific technology, they can change how learners practice and understand concepts in a particular content area. The notion of TCK was readily inferred from the TK above because the way the teachers used and applied the available technology in their classes reduced them to using what they had at their disposal. In T3 class, the only device he had was a laptop, and he relied solely on YouTube videos to demonstrate to learners. T6 used a TV to play a video; nothing else was more aligned with the latest digital tools. In the T9 class, no technology was used; the only tool was a whiteboard for taking notes. Although learners managed to follow what was said, it did not prepare them for the latest technology integration needed for the world of work.

Technological Pedagogical Content Knowledge (TPACK)

Sub-theme: A compromised amalgamation of content, technology, knowledge and digital tools' integration

The teachers demonstrated a good CK but a shallow TK, which was insufficient to expose learners to the state-of-the-art digital tools needed for the world of work, thereby affecting their TCK and eventually compromising their TPACK. Across the TPACK framework, when any one concept is weak, an individual's TPACK will be compromised, as evidenced by the findings.

Face-to-face interviews

The interviews shed light on which technologies the teachers use and why to prepare learners for their PAT. This was coupled with the question of whether the professional development workshops actually take place and how effective these trainings are. When asked about the frequency of top-up trainings that teachers attend, one theme emerged.

Theme 1: Top-up training is frequent

Most teachers agreed that they attend training in Electrical Technology, and most of these training sessions focus on the use of digital tools.

T2 said: *"We often go to the district education trainings and we come back very resourceful"*. This was attested by T5, who said: *"Since working in this school, I have attended six of the workshop trainings, and that helps a lot"*. T8 said: *"I have been exposed to many trainings each year, but these trainings end up being the same, so I end up not learning anything new"*. This was attested to by T11, who said: *"There is nothing new that we are learning in those trainings. We often get trained by the same service provider, get given the same material as the previous year and come back not having learnt anything new"*.

When asked about the challenges teachers face in preparing learners for PAT, a theme emerged.

Theme 2: Inadequate equipment

Teacher 4 said: *"Much as we do attend trainings that are organised by our education district, the machinery that we are exposed to is not available in our schools".* This was supported by T9, who said: "We get exposed to big machinery that is used in industries, but this machinery is *not available at work (school). So we do go to workshop trainings, get trained, and then come back to use YouTube videos because that is what we have. T11 said: "They train us on relevant machinery and leave us to make our own plans back at school, and that does not help us at all".*

When asked about the digital tools teachers have available, one theme emerged.

Theme 3: Lack of tools for PAT

T6 said: *"We do not have proper tools to prepare learners for PAT, and as such, learners end up doing a PAT that is not engaging because they cannot even research properly".* This was added by T10, who said: "We often run out of wiring equipment, *which is the centre of our PAT, and when we get to that point, we tell learners to end their PAT preparation there where tools are needed".* This was supported by T12, who said: "Learners *compromise on getting the relevant tools, just for them to submit a PAT that would give them 60%, so we do not have tools at all".*

When asked about learners' readiness for the world of work, most teachers said learners are not quite ready.

Theme 4: Underprepared learners for the corporate world.

T1 said: " *With this lack of proper equipment, we end up preparing learners who come out short of what the world of work wants".* This was added by T6, who said: *"When you do not have enough tools, your end product will always be compromised, and that is what we end up having".* The utterances add to what T9 said that *"lack of tools makes us not produce what industries can absorb, and this is beyond our control because we do not have tools".* T9 said: *"We struggle with tools here, we end up asking the learners to go do research, and they too do not have resources of their own, so we are both struggling".*

Discussions

The above findings show that, although teachers are qualified to teach Electrical Technology, the lack of tools and equipment deters them from doing what is necessary to prepare learners for the world of work. During the observation, it was found that most teachers lack the proper tools to teach the Electrical Technology subject. This makes them (teachers) unable to do proper simulations that bring the real world into the classroom. According to Mavhungu & Tlale (2022), simulations and virtual labs provide a safe, iterative environment for learners to test hypotheses and receive immediate feedback. This is not the case with learners in the schools where this study was conducted. Various studies have explored the use of simulations and digital media in electrical or physics-related education. Mustaqim et al. (2022) compared Livewire and Proteus simulation media in a problem-based learning setting for Basic Electricity

& Electronics and identified them as among the most helpful tools in Electrical Technology. However, some of the schools we have visited possess these tools. This is despite notable progress, as the Ministry of Education has embarked on teachers' professional development through regular workshops and training. However, several challenges continue to hinder the widespread use of digital tools in practical assessment. These include, among others, Infrastructure Inequality, where many schools lack computers, stable internet access, and up-to-date software licenses (Khumalo, 2020). The interviews revealed a lot from the teachers, who opened up about the daily challenges they face in administering PAT. The teachers cry foul on the digital divide that they face in schools. The digital divide is characterised by disparities in access to and use of technology, which pose a significant challenge in education, as espoused by Afzal et al. (2023). This, in turn, causes learners to exit the education system with shallow content knowledge (CK), which contributes to the increasing joblessness the country faces (Statistics South Africa, 2023). When the teacher demonstrates good CK but lacks support to infuse technology (TCK), their TPACK is affected, which influences the results PAT was supposed to achieve due to the scarcity of digital tools.

Recommendations

To enhance the effective integration of digital tools in Electrical Technology assessments, the following are recommended:

- Blended Assessment Models: Combine digital simulations with real-world practicals to ensure holistic competency evaluation. This will require the acquisition of proper equipment, which must be provided by the Department of Education or local sponsors, which is what is sorely missing in our schools.

- Teacher Training: The South African Council for Educators (SACE) and DHET should expand professional development workshops focused on digital pedagogy for technical subjects. However, such training needs to be conducted on machinery similar to that schools possess.

- Infrastructure Investment: Prioritise ICT development in under-resourced schools through partnerships with private sector initiatives. What we picked up is that many schools lack sponsors; they rely solely on the Ministry of Education to secure partnerships for them, and this needs to change.

Conclusion

The integration of digital tools has significantly transformed the nature of practical assessment in Electrical Technology within South Africa. These tools enhance safety, efficiency, conceptual understanding, and accessibility, particularly in contexts where physical resources are scarce. However, successful implementation depends on adequate infrastructure, teacher competence, and a balanced assessment approach that values both virtual simulations and hands-on performance. As South Africa advances toward 4IR-aligned education, embracing blended assessment models in Electrical Technology will be critical for producing competent, digitally literate artisans ready for the modern workplace.

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