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Teachers’ Perceptions Towards Practical Work in Chemistry Teaching: A Case of Selected High Schools in South Africa

Sakyiwaa Boateng[1*]
Simthembile Maroloma[2]

AFFILIATIONS
[1]Department of Mathematics, Science and Technology Education, Walter Sisulu University, Kamani, South Africa.

CORRESPONDENCE
Email: sboateng@wsu.ac.za*

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Abstract: This study examines how physical sciences teachers in South African high schools perceive the use of practical work in chemistry instruction. The study is grounded in the framework of social constructivism. Qualitative research methods, including semi-structured interviews and classroom observations, were employed to gather insights from a purposively selected sample of four high school chemistry teachers, each from a different high school. The aim was to explore their perspectives on the incorporation of practical work in chemistry teaching. Thematic analysis of the data revealed a range of insights into teachers' perceptions. The findings indicate that teachers recognise the value of practical work in engaging students and reinforcing theoretical knowledge. However, they also face several challenges that hinder its effective implementation, such as inadequate laboratory facilities, limited access to resources, time constraints, and insufficient teacher training. Despite these obstacles, teachers demonstrate a strong commitment to integrating practical work into their teaching and employ innovative strategies to overcome these barriers. They highlight the need for increased support from educational authorities in terms of resource provision, professional development opportunities, and curriculum alignment. The study provides recommendations for educational policymakers, curriculum developers, and teacher training institutions to address these perceived challenges and enhance the quality of chemistry teaching and learning in South African high schools.

Keywords: Experiment, laboratory, practical work, teacher perception, scientific inquiry.

1. Introduction

Physical science is an elective subject offered in South African high schools. Its main focus is the study of physical and chemical processes through scientific inquiry (DBE, 2011; Kibirige & Maponya, 2020). The subject's importance is increasing on a global scale due to its impact on scientific and technological advancements, which are crucial for the country's economic growth and the well-being of society as a whole. In light of this, the Physical Sciences Curriculum and Assessment Policy Statement (CAPS), issued by the Department of Basic Education in 2011, places greater emphasis on the use of practical work as both a teaching method and an assessment tool. Practical work is beneficial in enhancing conceptual knowledge when a connection is made between the learners' pre-existing scientific ideas and their practical experiences (Pun & Cheung, 2023). Therefore, many scholars argue that science teachers should ensure that their students actively participate in hands-on experiments and activities in order to enhance their understanding of natural phenomena and develop essential scientific process skills (Kibirige & Maponya, 2020; Nagy et al., 2022; Sukarno et al., 2019). Moreover, hands-on activities are particularly favoured in physical science education due to students' generally positive attitudes towards them, which can foster curiosity and self-efficacy beliefs (Nagy et al., 2022). It is crucial to create a supportive school environment that encourages exploration and hands-on engagement in scientific activities in order to enhance students' scientific process skills (Sukarno et al., 2019). However, there is an ongoing debate regarding the specific

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objectives of conducting science practical activities and how science teachers perceive hands-on activities.

From an international perspective, a study conducted by Kotuľáková et al. (2024) in Slovakia examined the perspectives of 33 chemistry teachers on practical activities in chemistry lessons. The teachers were asked to rank and sort 61 statements about practical activities according to their preferences. The analysis identified three distinct perspectives: (Factor 1) emphasis on experiencing phenomena, (Factor 2) teacher control, and (Factor 3) focus on the learning process. Another study by Shana and Abulibdeh (2020) explored learners' engagement with practical work and found that engaging learners in practical activities led to increased interaction with objects and an enjoyable learning experience. In the African context, Asamoah and Aboagye (2019) conducted a study in Ghana on teachers' perspectives on practical work. The findings revealed that practical work in science improved learners' practical and problem-solving skills, as well as solidified their understanding of science concepts. A similar study conducted in Ethiopia by Seid et al. (2022) investigated teachers' beliefs about practical work and its relevance to students' learning. The findings indicated that teachers believed practical work in science enhanced learners' practical and problem-solving skills. However, the study also highlighted teachers' concerns regarding the lack of laboratory apparatus and insufficient time for conducting practical work.

According to the Department of Basic Education (DBE) (2011) in South Africa, physical sciences is a highly sought-after subject in high schools. Despite its popularity, a significant number of learners consistently underperform in chemistry, particularly in Paper 2 of Physical Sciences. The National Diagnostic Analysis of the Outcomes of Paper 2 of NSC Physical Sciences over the past three years consistently demonstrated a trend of learners failing this subject (DBE, National Diagnostic Analysis, 2019; 2020; 2021; 2022). Similar findings were also documented in prior diagnostic reports from 2015 to 2018. Upon closer examination, it was found that certain topics, such as acids and bases, organic reactions, and rate of reactions, posed challenges for learners, particularly in their application of practical work (DBE, 2022).

The comprehension of scientific concepts related to practical work poses a challenge for learners, potentially due to insufficient guidance provided by teachers during the teaching-learning process (Teppo et al., 2021). In particular, teachers often express that their professional development opportunities relating to practical work in chemistry are inadequate (Akuma & Callaghan, 2018). This lack of training negatively affects teachers' confidence and proficiency in conducting experiments, consequently impacting their beliefs, willingness, and ability to incorporate practical work into their teaching practices. Additionally, based on our experience as high school teachers, we have observed a notable scarcity of resources in many high schools. These resource constraints impede teachers' ability to effectively integrate practical work into their curriculum. As a result, the extensive theoretical content that must be covered within a limited timeframe often takes precedence over practical activities, which are viewed as time-consuming (Malathi & Rohini, 2017). Ramnarain (2014) argues that the influence of intrinsic and extrinsic factors on practical work offers a framework for understanding the factors that may influence teachers' perceptions of practical work in chemistry teaching, thereby highlighting the concerns teachers have regarding practical work.

Numerous studies have emphasised the value of learning physical science through hands-on experiences rather than through passive forms of instruction (Gericke et al., 2022; Seid et al., 2022; Shana & Abulibdeh, 2020). However, there is a scarcity of studies examining teachers' perceptions of practical work in physical science (Asamoah & Aboagye, 2019; Kibirige & Maponya, 2020), and limited research has been conducted on teachers' perceptions of the use of practical work in teaching and learning chemistry in high schools in South Africa's Eastern Cape province. In light of this gap, this study aims to explore teachers' perceptions regarding the use of hands-on experiments, demonstrations, and laboratory activities to enhance high school students' learning experience and understanding of chemistry concepts in South Africa. By examining teachers' perceptions, this research intends to shed light on the challenges, benefits, and overall effectiveness of integrating practical work into chemistry education within the context of South African high schools

1.2 Research questions

The research questions that guided the study are as follows:

- How do physical sciences teachers perceive the effectiveness of practical work in enhancing learners' understanding and retention of chemistry concepts?
- How do physical sciences teachers engage learners in practical work while teaching and learning chemistry?
- What challenges do physical sciences teachers face regarding teaching practical work in chemistry in rural schools?

2. Literature Review

2.1 Perceptions of teachers towards the effectiveness of science practical work

The perspectives of teachers regarding the efficacy of science practical work have a significant influence on the implementation of science education practices. Practical activities, laboratory work, and practical work are considered integral components of chemistry education. The studies conducted by Hofstein et al. (2013), Gericke et al. (2022), and Abdussyukr et al. (2021) provide diverse viewpoints on the importance of practical work in science education, particularly in the realm of chemistry instruction. Hofstein et al. (2013) underscore the significance of practical activities in chemistry education, highlighting how these experiences enable students to interact with apparatus, gather data, and enhance their understanding of the natural world. They argue that practical work is a fundamental aspect of teaching scientific concepts and processes. Conversely, Gericke et al. (2022) propose that practical activities are essential for both acquiring scientific concepts and engaging in scientific inquiry, emphasising the role of hands-on experiences in the learning process. Abdussyukr et al. (2021) further support the notion that recognising the value of practical work enhances teachers' capacity to facilitate students' grasp of scientific concepts, emphasising its crucial role in developing learners' practical skills. Nevertheless, Asmah et al. (2021) and Asamoah & Aboagye (2019) provide critical insights into the practical implementation of practical work in chemistry instruction. Asmah et al. (2021) highlight a disconcerting tendency among teachers to prioritise exam-centred teaching over fostering practical skills among students, thereby neglecting their comprehensive development. Correspondingly, Asamoah and Aboagye (2019) echo these sentiments, noting that numerous teachers primarily employ practical work for examination purposes rather than to deepen students' comprehension of scientific concepts. These studies underscore the prevalent issue of practical work being underutilised to enhance students' scientific knowledge and skills. Furthermore, Piaget and Cook (1952) and Adamu and Achufusi-Aka (2020) contribute to the discourse by emphasising the impact of teachers' attitudes toward practical work on student engagement and interest in science. Piaget and Cook (1952) suggest that early exposure to practical work is crucial for students' development across various stages.

The study conducted by Kibirige and Maponya (2020) and the research carried out by Ramnarain (2014) present divergent perspectives on the role of practical work in science education, particularly in the context of South Africa. Kibirige and Maponya's (2020) study investigates the attitudes of Grade 11 Physical Science teachers towards the incorporation of practical work in the classroom. This study provides insights into the perspectives and practices of teachers regarding the implementation of hands-on activities. The study emphasises the significance of understanding teachers' opinions in order to navigate the challenges and opportunities associated with the integration of practical work in science education. In contrast, Ramnarain's (2014) research presents a different viewpoint. According to this study, science teachers consider practical work as a means to enhance the appeal of science topics and improve students' experimental skills. However, a noteworthy finding indicates that some teachers do not view hands-on activities as fundamental for developing a profound understanding of scientific concepts. Additionally, a portion of the teachers believe that their explanations are more effective than practical work in enhancing students' comprehension of scientific subjects. These teachers prioritise the acquisition of in-depth knowledge over practical application.

In response to these perspectives, Seid et al. (2022) challenge the existing status quo with their findings. Their study suggests that although teachers acknowledge the importance of practical work in teaching science, its implementation in schools is infrequent. This study highlights a disconnect between teachers' beliefs regarding the significance of practical work and the actual practice in educational settings. The discrepancy identified by Seid et al. (2022) raises questions about the feasibility and effectiveness of teachers' attitudes towards practical work in science education.

2.2 Teachers’ engagement with practical work during science teaching and learning

The CAPS physical sciences curriculum places a high priority on the practical application of scientific principles rather than solely focusing on the acquisition of scientific knowledge and concepts (DBE, 2011). Through hands-on activities, learners develop crucial abilities such as analytical reasoning, effective problem-solving, and a proactive approach to learning, which are often lacking when students simply follow instructions. However, the CAPS physical sciences policy statement (DBE, 2011, p. 11) specifically outlines the abilities that learners must acquire during practical work, as specified in the assessment guidelines. It is expected that students cultivate these abilities through their participation in practical, cognitive, and emotional activities during physical sciences sessions.

Teachers play a crucial role in facilitating practical work in science classrooms by guiding students through experiments and fostering a culture of inquiry and exploration. Vivante and Vedder-Weiss (2022) emphasise the pivotal role of teachers in engaging students in practical work, highlighting the need for continuous professional development to enhance teaching practices. On the other hand, Davis and Palincsar (2022) found that teachers' engagement in science teaching practices varied depending on the lesson and school context, emphasising the influence of the learning environment on teacher practices. This discrepancy raises questions about the consistency of teacher engagement in practical work across different educational settings. Tekkumru-Kisa et al. (2017) advocate for the use of video-based training to improve teachers' ability to promote critical thinking skills among students. In contrast, Cairns and Areepattamannil (2019) argue that teachers are inadequately implementing inquiry-based science teaching techniques, suggesting a gap in the application of inquiry-based instruction in science education. They contend that inquiry-based instruction should focus on facilitating learners in acquiring scientific knowledge through hands-on experiments rather than passive reception of information from teachers. Woodley (2009) highlights the recognised significance of hands-on experimentation in science education, noting that practical work enhances student engagement, enthusiasm, and the development of various skills and scientific knowledge. The varying perspectives presented in these studies reinforce the complexity of integrating practical work in science classrooms and the need for further research and support to enhance teachers' ability to effectively engage students in hands-on activities.

2.3 Challenges of implementation of science practical work in schools

The implementation of science practical work in schools is faced with numerous challenges that can have an impact on the effectiveness of science education. These challenges encompass various aspects, ranging from resource limitations to pedagogical barriers, which in turn can affect the quality and frequency of practical work experiences for students. Resource constraints, such as a lack of laboratory equipment, materials, and facilities, pose a significant challenge when it comes to implementing science practical work in schools (Chala, 2019; Malathi & Rohini, 2017). Without sufficient resources, teachers may encounter difficulties in providing hands-on experiences that are crucial for reinforcing scientific concepts and skills.

Furthermore, the study conducted by Niyitanga et al. (2021) revealed additional challenges, including inadequate motivation among teachers, insufficient proficiency in designing adaptable and innovative lessons, and a lack of understanding of the curriculum goals, all of which have a detrimental impact on the implementation of science practical work. We contend that misalignments between teachers' instructional approaches and the objectives of practical work can result in inconsistencies in students' experiences and learning outcomes. As highlighted by Malathi and Rohini (2017), class size, student engagement, and classroom management issues can also impede the successful implementation of science practical work. Factors such as the reluctance of some science teachers to conduct practical work and the incompetence of certain teachers in teaching science using practical activities have been identified as barriers to the implementation of practical activities (Paterson, 2019).

3. Theoretical Framework

The study was conducted within the theoretical framework of social constructivism (Hyslop-Margison & Strobel, 2007; Vygotsky, 1978). Social constructivism theory serves as a basis for evaluating teachers' perspectives on the importance of practical work in education, highlighting the active construction of knowledge through social interactions and experiences. According to this theory, learning involves actively seeking and creating meaning, which requires a comprehensive understanding of both complete entities and individual components (Detal, 2015; Wink, 2014). Each individual develops their own set of rules and mental frameworks that they employ to make sense of their experiences. Consequently, Allen and Bickhard (2022) have emphasised that the ultimate goal of learning is for individuals to independently develop their understanding.

To effectively engage learners in the learning process, it is essential to comprehend the frameworks that learners employ to interpret their environment, as well as the underlying assumptions that support these frameworks. This can be achieved by fostering collaborative learning environments and providing hands-on experiences in education (Detel, 2015). In the present study, we contend that teachers' perspectives on the significance of practical work in schools are influenced by their social connections, professional backgrounds, and educational beliefs. Given that constructivism theory emphasises the importance of considering teachers' perceptions as practical knowledge that shapes their judgment and behaviour in the classroom, it would be advantageous to examine teachers' views on the importance of practical work in teaching chemistry. This study employed this theoretical framework to explore teachers' perspectives on the importance of practical work in chemistry instruction, with the aim of addressing the existing challenges in teaching practical work in high schools.

4. Methodology

The interpretivist paradigm plays a crucial role in conducting studies on the significance of practical work in the field of sciences. This paradigm is grounded in humanist assumptions that prioritise the understanding of individuals' subjective experiences and the social constructs that shape their realities (Pervin & Mokhtar, 2022). When conducting research within the interpretive paradigm, qualitative methods are typically employed to delve into the intricate nuances of human experiences and the meanings attributed to them. In this study, a qualitative approach was chosen as it was considered suitable for extracting meaningful insights from the perspectives of the participating teachers (Lewis, 2015). By allowing the participants to express their viewpoints on practical work in chemistry teaching in high schools and elucidate their strategies for engaging learners during practical work, this study provides valuable insights.

This study utilised a case study design (Yin, 2018) to examine teachers' perspectives on the significance of practical work in chemistry instruction. This allowed the researchers to offer a detailed account of the teachers' views and involvement in practical work, as well as comprehensive information on any difficulties they may have while engaging learners in practical activities. A case study design was used to examine how teachers in four different schools carry out practical work and their impressions of it, as well as the problems they face. Each school was considered as an individual case or unit. According to Merriam (2015), researchers can enhance the interpretation of their findings by examining several examples, which allows for greater diversity between the cases.

4.1 Population and Sample

The target population for this study comprised all teachers who teach physical sciences in rural high schools in the O.R Tambo Inland region. To select the research sites and participants for this study, we employed purposive sampling (Andrade, 2020). The sample consisted of four physical sciences teachers chosen from four rural high schools. Within each school, one physical sciences teacher was chosen based on criteria such as age, gender, qualifications, grade level of instruction, past performance of learners, and years of teaching experience. The selection of four teachers from four schools was aimed at capturing a wide range of experiences and perceptions. Each school possesses unique resources, administrative support, student demographics, and cultural contexts that influence the perception and implementation of practical work. This diversity aids in understanding the broader spectrum of challenges and opportunities faced by chemistry teachers. Additionally, focusing on four teachers allows for a manageable scope of data collection and analysis. Given the intensive nature of qualitative research methods, selecting a small, purposeful sample is practical and ensures a thorough exploration of each participant's perspective. This, in turn, can reveal nuanced insights into their perceptions of the role of practical work in chemistry education. By including teachers from various schools, the findings are more likely to resonate with a broader audience, facilitating the application of insights to other teachers and policymakers in their respective contexts.

4.2 Data collection instruments

We utilised semi-structured interviews and classroom observation as our selected methods for data collection. The interview questions were divided into two distinct sections: Section A and Section B. Section A focused on the teachers' educational background, including their teaching experiences, qualifications, and the subjects and grades they taught. In Section B, the interview primarily addressed the teachers' perceptions of practical work, their strategies for engaging students in practical activities, and the potential challenges they may encounter during practical work. Data collection commenced during the second semester of the academic year in 2023. After obtaining ethical approval from the Eastern Provincial Education office, we visited the selected schools and sought permission to conduct the study. We established a positive and trustworthy relationship with each of the selected schools and the science teachers who were part of our sample. We conducted individual semi-structured interviews to ensure that participants provided comprehensive responses. The interviews and classroom observation sessions were both recorded and transcribed. Each interview had a duration of 45 minutes, while each classroom observation lasted for the entire one-hour period.

4.3 **Data analysis** and **ethical consideration**

We employed thematic data analysis (Braun & Clarke, 2021) to examine the data. We captured and transcribed the data independently. Following Braun and Clarke's guidelines, we identified patterns and categorised them into themes within the data. We took into account our own perspectives and biases, enhancing the rigour of the analysis process.

To ensure the trustworthiness of our data, we maintained methodological transparency by clearly outlining the research design, data collection methods, and data analysis procedures. We also conducted interviews and classroom observations to strengthen the credibility and dependability of the study. We engaged in member checking, where participants reviewed and validated the findings, thereby enhancing the trustworthiness of the research. Additionally, we employed a systematic and thorough approach to data analysis, which helped uncover patterns and themes in teachers' perceptions.

We followed and abided by ethical guidelines. Official correspondence was sent to the Department of Education in the Eastern Cape Province, requesting permission to conduct the study. Letters seeking permission were sent to the managers of the four schools, and science teachers were asked for their explicit approval. Informed consent was obtained from all participants prior to their involvement in the study, ensuring that they were fully informed about the purpose, procedures, risks, and benefits of the research and that their participation was voluntary and confidential. The participants explicitly expressed their agreement to take part in the study.

5. Presentation of Results

The results are presented below and were made to respond to the research questions raised earlier. This was begun by presenting the biographic background of physical science teachers.

5.1 Biographic background of physical sciences teachers

Table 1: *Physical sciences teachers' profile*

Teacher	Age	Teaching experience	Race	Gender	School Code	Qualification
TA	32	8	Black	Female	School A	B.Ed Maths/Science.
TB	45	18	Black	Male	School B	BSc, PGCE Physical Sciences.
TC	28	4	White	Male	School C	BSc, Hons Physical Sciences.
TD	38	12	Black	Female	School D	BSc, PGCE Physical Sciences.

Table 1 above provides background information on the participants involved in the study. Two females and two males from four schools were sampled for the study. The participants have taught physical sciences for the past four to eighteen years. All the participants hold a bachelor's degree in sciences, one with an Honours degree in science and two with a postgraduate diploma in Education. Three of the participants are Africans, one of whom is a white male.

5.2 Theme presentation

The data obtained from teachers was categorised into three main themes: teachers' perception of the effectiveness of practical work, teachers' engagement with practical work and challenges teachers experience when implementing practical work.

Theme 1: Perceptions of the effectiveness of practical work in chemistry teaching

Examining the perceptions of physical sciences teachers regarding the incorporation of practical work in chemistry education revealed nuanced insights. Many participants expressed a strong belief in the value of hands-on activities, asserting that they significantly enhance students' understanding of chemistry concepts. Participants uniformly attested to the effectiveness of practical work in science instruction, as exemplified by Participant TB's statement, while Participant TA concurred, stating:

> " *I firmly believe that practical work is indispensable in teaching chemistry. It offers learners the opportunity to experience abstract concepts, promoting a deeper understanding. For instance, when I conduct experiments on chemical reactions, learners not only see the reactions happening but also understand the underlying principles behind them.*"

> "*I've been teaching chemistry for over a decade, and practical work has always been at the core of my teaching approach. It's not just about demonstrating chemical phenomena; it's about nurturing curiosity and a hands-on approach to learning. When learners actively engage in practical work, they become more invested in the subject, and their understanding goes beyond memorisation. Practical work also allows for differentiation, catering to diverse learning styles and abilities in my classroom.*"

Participants emphasised the transformative impact of practical work on learning outcomes, emphasising its ability to stimulate learner interest, foster deeper understanding, and demystify complex concepts. Participant TC articulated:

> " *Implementing practical work ignites curiosity and facilitates a deeper understanding of chemistry concepts, offering my learners a concrete experience that enhances their understanding and promotes their engagement in the teaching and learning process* ".

Regarding the prerequisites for effective practical work, participants identified a blend of passion, content expertise, and resource availability as essential components. Participant TD emphasised the significance of a comprehensive understanding of chemistry content across the syllabus, noting:

> " *We as physical science teachers must possess a robust grasp of chemistry concepts to effectively guide our learners' practical activities.* "

Participant TB echoed this sentiment, emphasising the importance of enthusiasm for practical work and the availability of resources alongside the knowledge required to conduct experiments safely. The participants emphasised the crucial role of practical work in providing students with real-world applications and connections to theoretical concepts. Participant TA remarked:

> " *Practical work bridges the gap between theory and practice, allowing students to apply classroom knowledge to real-life scenarios, thereby enhancing their understanding and appreciation of chemistry.* "

This implies that integrating practical work in the teaching and learning of chemistry enhances learners’ understanding of the concept and enables them to relate the abstract concepts in chemistry education.

Theme 2: Teachers' engagement with learners in practical work during the teaching and learning of chemistry

Incorporating practical work into the instruction of chemistry is an essential component of teaching, as emphasised by insights gathered from the physical sciences teachers who participated in the study. The participants held the belief that utilising diverse strategies to engage learners, alongside demonstrations to elucidate fundamental principles actively, plays a crucial role in fostering conceptual understanding among students in the subject. One participant, referred to as TA, underscored the significance of affording learners the chance to conduct their own demonstrations as they engage in a hands-on learning experience.:

> " *Yes, I give them time to do the demonstrations themselves, having explained all that is expected*".

Participant TD highlighted the reliance on group demonstrations due to resource constraints, stating:

> " *I mostly use group demonstrations where I put learners together as a group to engage in the demonstration activity during practical work*".

Participant TB emphasised the importance of hands-on experimentation in helping learners grasp complex concepts and develop a deeper interest in the subject, stating:

> " *Seeing is believing. Chemistry concepts are too complex to be easily learned in the classroom, so experimenting helps learners to understand chemistry topics better. However, I do not engage my learners in practical activities because of constraints on resources. I often try to explain practical activities instead of engaging learners in those activities.”*

Participants mentioned exploring other novel avenues to enrich and engage learners in practical work experiences in chemistry education. One approach embraced by one of the participants revolves around gamified learning experiences. As expressed by Participant TD,

> "*Although I teach in a rural school, I am a technophile. I like to incorporate digital tools into my lessons to engage my learners. Especially during practical work, I use gamified challenges during practical sessions not only to make learning fun but also encourage healthy competition among learners, driving them to excel and explore beyond their comfort zones*."

This implies that by infusing elements of interactivity into practical work activities, teachers can ignite learners' enthusiasm and motivation in the physical sciences classroom.

Theme 3: Challenges to implementing practical work in chemistry

This theme responded to research question three. Three sub-themes were generated based on the data from the participants. The challenges are stated below:

Sub-theme 1: Challenges teachers encounter when implementing practical work

The journey towards effective implementation of practical work in chemistry education is filled with challenges, as expressed by the participants. Participants observed that they faced challenges, including a lack of resources in their schools. This shortage not only hinders the range and depth of hands-on experimentation but also undermines the quality of practical learning experiences. Therefore, the participants mentioned that they often find themselves struggling with the limitations imposed by the absence of fully equipped laboratories, relying on temporary solutions such as basic science kits, which, although functional, do not provide comprehensive practical exposure to high school students. Participant TD expressed frustration with insufficient equipment and expired materials, stating:

> " *The main challenge is getting enough equipment in my school. Sometimes even the available materials and chemicals tend to expire, and worse is the large class size* "

Participant TD’s sentiment was echoed by TA indicated the following frustrations:

> *“One of the main challenges I face when implementing practical work in chemistry is the lack of adequate laboratory facilities and resources. It's often difficult to conduct experiments when there aren't enough materials or equipment available for all learners. This not only hampers the learning experience but also demotivates both myself and my learners.*"

Participant TC raised the concern about time constraints.

> *"Time constraints are a significant challenge. Planning and executing practical work requires a considerable amount of time, which is often limited due to the pressure of covering the CAPS curriculum and my workload. Balancing between completing theoretical content and allowing sufficient time for hands-on activities is a constant struggle*."

Despite recognising the benefits of practical work, teachers cited constraints on the frequency of implementation. Most conduct practical work only once a term due to tight school schedules and limited resources. Participant TB lamented the challenges of preparation, including sourcing materials, verifying chemical availability, and ensuring learner readiness, stating:

> " *My school has an hour slot for every lesson. There are large class sizes. There is no way I could engage learners in meaningful practical work within one hour. I still have to find the required material, to look for relevant information, such as videos with stern instructions on how to do the practical*"

Another challenge raised by the participants was safety concerns during practical sessions. Ensuring the safety of learners while conducting experiments requires strict supervision and adherence to safety protocols.

Some participants were of the view that some learners are not motivated enough to participate in practical activities and often do not engage in the sessions as they know that they will get marks equally from the others as a group. TA shares this sentiment:

> "*Learners' engagement and motivation can also be challenging when implementing practical work. Some learners may lack interest or see it as merely a requirement rather than an opportunity to deepen their understanding".*

Despite acknowledging the benefits of practical work, participants expressed their frustration with the ongoing obstacles presented by restricted resources and infrastructure. The general consensus among the participants was that the insufficient availability of laboratory facilities and equipment undermines the quality of learners' educational experiences, impeding their capacity to actively participate in hands-on experimentation.

Sub-theme 2: Strategies employed by teachers to overcome challenges in teaching practical work

The participants elucidated a multitude of strategies they employ in order to navigate the challenges inherent in teaching practical work in the field of chemistry. In their quest to overcome these challenges, the participants expressed a need for heightened support from the Department of Basic Education, including the provision of adequately equipped laboratories and additional practical work activities for schools. Participant TC underscored the significance of laboratory facilities in facilitating practical work, emphasising:

> " *If only the schools could be provided with well-equipped laboratories, as it is the best place to conduct practical work, especially in chemistry.* "

Some participants advocated for alternative methods to facilitate practical learning experiences for learners. Participant TD emphasised the importance of resourcefulness, stating:

> " *Yes, I have improvised; make use of the resources available and space that you have, while also advocating for the use of simulations, models, and multimedia resources to supplement practical work".*

One common approach involves leveraging available resources creatively to make the most out of limited facilities and equipment. For instance, some participants mentioned modifying experiments to suit the available materials or improvising alternative tools when necessary. Participant TA remarked:

> "*I often have to think outside the box and find innovative ways to conduct experiments with the resources my school has at my disposal.*"

Additionally, some participants highlighted the importance of advocacy and collaboration with school principals and educational authorities to address the lack of infrastructure and secure funding for laboratory resources.

6. Discussion of Findings

The study investigates the perceptions of high school teachers in South Africa regarding practical work in chemistry teaching. The research explores various themes related to the effectiveness, relevance, engagement, and challenges associated with practical work in chemistry education. The first theme addresses the teachers' perspectives on the effectiveness of practical work, revealing a range of viewpoints on the importance of hands-on experiments in teaching chemistry. The teachers emphasise the value of practical experiences in enhancing students' comprehension of abstract concepts and fostering a deeper appreciation for the subject. This perspective aligns with previous studies conducted by Nagy et al. (2022), Sukarno et al. (2019), and Pun and Cheung (2023), all of which highlight the critical role of hands-on activities in science education. This finding is further supported by Vygotsky's (1978) constructivist theory, which suggests that knowledge is constructed through experience and emphasises the active role of learners in knowledge acquisition. The study also reveals that teachers' belief in the relevance of practical work positively influences students' educational experiences and academic performance in chemistry. This finding echoes the results of studies conducted by Shana and Abulibdeh (2020) and Asamoah and Aboagye (2019), which emphasise that practical work enhances students' practical and problem-solving skills while also promoting enjoyment and engagement with the subject. Furthermore, a study conducted in Ethiopia by Seid et al. (2022) further supports the notion that practical work improves students' practical and problem-solving skills, underscoring the benefits of hands-on experiences in science education.

The second theme examined the involvement of physical sciences teachers in hands-on activities during the teaching and learning of chemistry. According to the principles of social constructivism, knowledge is actively constructed through social interactions, engagement, and experiences, emphasising the significance of collaborative learning environments and experiential learning in education (Detel, 2015). The research revealed that learners were given opportunities to participate in practical work both individually and as a group, allowing them to demonstrate their results and engage in discussions with their peers. This finding aligns with Vivante and Vedder-Weiss's (2022) study, which emphasises the importance of teachers' involvement in hands-on activities and highlights the necessity for continuous professional development to enhance teaching practices and improve the learning experiences of students. These findings are also consistent with Davis and Palincsar's (2022) study, which found that teachers' engagement in science teaching practices varied depending on the lesson and the context of the school, highlighting the influence of the learning environment on teaching practices. The study further revealed that participants utilised various strategies to enhance and engage learners in practical work. This finding is in accordance with Tekkumru-Kisa et al.'s (2017) study, which emphasised the impact of video-based professional development on teachers' ability to facilitate higher-order thinking skills among students, emphasising the importance of reflective practices in teaching while students are engaged in practical work.

The third theme explores the difficulties faced by teachers when incorporating practical work into their chemistry instruction. The study revealed that teachers identified numerous obstacles that hindered the successful execution of practical work in chemistry education. Particularly, the insufficiency of resources emerged as a prevalent concern, with many teachers expressing concerns about inadequate funding, outdated laboratory facilities, and shortages of essential equipment and chemicals. This discovery aligns with Chala's (2019) research, which also identified the shortage of apparatus and chemicals as a primary challenge that impedes the implementation of practical work in chemistry classrooms. Consequently, limited resources not only constrained teachers' ability to conduct experiments but also compromised the quality of practical learning experiences for students.

Furthermore, the study uncovered logistical challenges, including overcrowded classrooms, issues relating to class size, student engagement, and classroom management. These challenges significantly impacted teachers' implementation of practical work. This finding is consistent with the conclusions drawn by Malathi and Rohini (2017), who similarly found that large class sizes hindered personalised attention and hands-on experiences for students. Additionally, maintaining student engagement during practical work sessions posed a challenge for teachers. Moreover, the study revealed that some teachers' hesitance or lack of competence in teaching science through practical activities posed additional challenges to the implementation of practical work. This finding aligns with the results of Paterson's (2019) research on factors that hinder the effective implementation of practical activities.

7. Conclusions and Recommendations

In conclusion, the study on teachers' perceptions of the role of practical work in chemistry teaching in rural schools reveals several critical factors that influence the implementation of practical work in chemistry classes. Utilising social constructivism as a lens, the study presented compelling evidence that teachers perceive the significance of practical work in chemistry education. However, learners are not actively engaged in practical activities due to the absence of an equipped laboratory, insufficient resources, lack of pedagogical content knowledge in practical work, and limited time. The findings provide evidence of the challenges that contribute to low learner performance in the subject. Therefore, this study offers valuable insights into how teachers perceive ways to enhance the quality of teaching and learning in chemistry practical activities, to improve student knowledge and abilities in chemistry. Nonetheless, the study was limited to four schools that were purposefully sampled. This limitation does not provide a more holistic picture of teachers' perspectives on practical work and their approaches to engaging learners in practical activities.

This study presents an approach to improving the academic achievement of Grade 12 learners in practical work, particularly by examining how teachers perceive the effectiveness of practical work in engaging learners in chemistry lessons. As the study progressed, certain themes emerged as suitable subjects for further investigation. It is recommended that teachers adopt a learner-centred approach in their classrooms, ensuring that instruction includes practical work, some control over assessment tasks, and comprehensive curriculum coverage. This would enhance learners' understanding and motivate them to improve their performance in future chemistry-related practical questions.

It is also recommended that chemistry teachers attend professional teacher development workshops to address content gaps and enhance their pedagogical and content knowledge of practical activities in the physical sciences, especially chemistry. Furthermore, it is suggested that teachers utilise demonstration methods and approaches that enhance students' concentration and motivation to improve their academic performance in the physical sciences. To enhance teachers' motivation to conduct practical work, the DBE should collaborate with non-governmental organisations to provide well-equipped laboratories for practical work in all schools.

8. Declarations

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