Available online at: https://jurnal-fkip.ut.ac.id/index.php/ijrse/issue/archive
International Journal of Research in STEM Education (IJRSE)
ISSN 2721-2904 (online)
Volume 6 Number 1 (2024): 97 - 112

Inquiry-Based Science Education: Perspectives from Namibian Teachers

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Abstract

In the evolving landscape of secondary school science education in Namibia, there is a growing shift from traditional rote-learning methodologies toward inquiry-based instruction and practical work to foster deeper learner engagement and critical thinking skills. This study, utilizing a sequential explanatory mixed methods approach, investigates the perceptions and practices of Namibian secondary school teachers regarding the implementation of inquiry-based science education. Despite the national curriculum's strong endorsement of learner-centered approaches, findings indicate a discrepancy between policy aspirations and classroom realities. Many teachers continue to rely on traditional methods due to persistent challenges such as inadequate resources, insufficient professional development, and entrenched instructional habits. However, those teachers who have adopted inquiry-based strategies report enhanced student engagement and a more profound understanding of scientific concepts among learners. This paper underscores the necessity for targeted professional development and resource allocation to bridge the gap between educational policy and practice, ultimately aiming to enrich science education through effective inquiry-based learning environments.

Keywords: *Teachers' conceptions, Teaching science, Inquiry-based instruction, Science practical work, Pedagogical approaches*

INTRODUCTION

Every country, including Namibia, recognises the critical necessity of science education in the twenty-first century. The inclusion of science learners in practical work and hands-on learning experiences is one of the most contemporary issues in science education in Namibia and across the globe (Sshana & Abulibdeh, 2020; Shivolo, 2018; Wei, Chen, & Chen, 2019; Lee & Sulaiman, 2018; Wei & Li, 2017). Muyoyeta (2018) is in agreement of the idea that science education is essential for a prosperous living in any community and that it is fundamental to providing the resources needed for a nation's socioeconomic, scientific, and technological growth. In a bid to develop a more comprehensive understanding of the natural world, learners engage in a variety of classroom activities known as 'practical work', which involve interacting with equipment and materials as well as any other type of secondary data and apprehending their findings (Wei, Chen & Chen, 2019; Hofstein, Kipnis & Abraham, 2013; Wei & Li, 2017; Abrahams & Reiss, 2012).

Practical work is regarded as a constructivist-based learning strategy where learners are encouraged to engage with real-world phenomena in order to evaluate their personal viewpoints and deepen their knowledge of what they are learning (Lee & Sulaiman, 2018). The researchers are of the idea that involving learners in hands-on activities is related to supporting teachers in reaching particular milestones in curriculum learning objectives in Namibian science classes, in particular.

In contrast to learners taught science through traditional pedagogical methods emphasising theoretical learning, those who actively engage in experiential, hands-on approaches to teaching and learning have

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DOI: https://doi.org/10.33830/ijrse.v6i1.1635

demonstrated advanced academic performance (Lee & Sulaiman, 2018). Additionally, Lee and Sulaiman (2018) discovered that if teachers effectively organise and carry out practical work in the classroom, the learning process in which learners acquire science information is improved. According to Jokiranta (2014), practical work can help learners conceptualise knowledge from science and also inspire them to learn science. Practical work encourages experiential learning, enables learners to discover realities not covered in textbooks, and allows them to apply concepts based on first-hand knowledge (Twahirwa & Twizeyimana, 2020).

The term inquiry has historically been described by Linn, Davis and Bell (2004) as a deliberate process of problem-solving, problem-diagnosing, evaluating experiments and identifying alternatives, planning investigations, researching conjectures, searching for information, building models, and engaging in peer debates while using evidence and representations to develop cogent arguments. In pursuit of the objective of this study, scholars within the academic community have characterised teachers' conceptions as encompassing a collection of factors, perspectives, ideas, and beliefs that pertain to teachers' perceptions of the teaching and learning processes. These conceptions have been posited to impede teachers' ability to implement inquiry-based instruction and practical activities within their classrooms (Caravias, 2018; Taylor & Booth, 2015; Bueno, 2013; Yung, Zhu, Wong, Cheng & Lo, 2013).

Subsequently, this study is centred on the objectives of comprehending, acknowledging, and documenting the conceptions held by science teachers in Namibia pertaining to the delivery of science practical work through the utilization of inquiry-based instructional pedagogy, with the overarching goal of bringing about change and improvement in the teaching of science at secondary school level.

Research Objectives

In this sequential explanatory mixed methods study, the researchers attempted to establish the Namibian secondary school teachers' conceptions of teaching science (Physical Science, grades 8 and 9; Physics and Chemistry, grades 10 and 11) through practical work and IBI. Thus, this study was guided by these two research questions:

1. What are the science teachers' conceptions of inquiry-based instruction?
2. What factors are informing science teachers' usage and enactment of inquiry- based instruction in their science practical work?

LITERATURE REVIEW

Understanding Teacher Conceptions

The concept of 'conception' in educational contexts refers to the cognitive representation of one's thoughts about a given phenomenon, as outlined by Matos and Jardilino (2016). This definition expands the understanding that teachers' conceptions influence their approach to science pedagogy, encompassing beliefs, perspectives, actions, and instructional strategies (Taylor & Booth, 2015). Mokiwa and Nkopodi (2014) further elaborate that such conceptions are shaped by factors including cultural backgrounds, educational experiences, and technical proficiency, highlighting the deep-rooted influences that mold educational practices.

Within this framework, the role of Pedagogical Content Knowledge (PCK) is instrumental. Introduced by Shulman (1987), PCK blends content and pedagogy into a coherent strategy for teaching, emphasizing the adaptation of teaching methods to meet diverse student needs. This concept has evolved to highlight the dynamic relationship between a teacher's mastery of subject content and their pedagogical techniques, which significantly impacts teaching strategies and student achievements in science (Keller et al., 2017; Nilsson & Loughran, 2012).

Science Teaching Orientations (STOs), a core component of PCK, reflect broader pedagogical beliefs that guide science teachers' instructional practices. These orientations help shape the goals and methods of science education at various educational levels (Magnusson, Krajcik, & Borko, 1999). Cobern et al. (2014) introduce a conceptual framework that situates STOs within a spectrum of science teaching expertise, categorizing instructional approaches into modes like didactic direct, active direct, guided inquiry, and open inquiry. This framework illustrates the pivotal role of STOs in transmitting scientific knowledge effectively, tailored to the unique educational contexts and needs of students.

In summary, the interplay between teachers' conceptions, PCK, and STOs creates a complex tapestry that influences the effectiveness of science education. Understanding and enhancing these components are crucial for developing instructional strategies that not only convey scientific knowledge but also engage and inspire students, preparing them for a world where science and technology play integral roles. This approach demands continuous reflection and adaptation from educators to ensure that teaching practices remain responsive to the evolving educational landscape and the diverse needs of students.

Science Practical Work in Teaching and Learning

In many countries of the world, science education places significant emphasis on practical work, as indicated by several researchers (Sshana & Abulibdeh, 2020; Wei, Chen & Chen, 2019; Lee & Sulaiman, 2018; Wei & Li, 2017; Nivalainen, Asikainen, Sormunen & Hirvonen, 2010). Practical work encompasses activities that necessitate learners to interact with real-world objects and materials, either individually or in collaboration, (Sshana & Abulibdeh, 2020); Lee & Sulaiman, 2018; Hofstein et al., 2013).

Within the advocacy of the National Research Council (NRC) (2012), practical work in science education is defined as activities that may expose learners to data about the natural world, which may not necessarily pertain directly to their immediate surroundings. In North America, practical work, often referred to as 'laboratory work' is characterised by a wide range of hands-on activities employed by teachers in primary and secondary school science classrooms (Hofstein et al., 2013; Wellington & Ireson, 2012).

Phrases such as 'laboratory work' and 'practical work' are often used interchangeably; however, practical work encompass experiments conducted in diverse settings, including outdoor environments, classrooms, and laboratories, while laboratory work specifically refers to experiments conducted within a laboratory (Motlhabane, 2013; Wei, Chen & Chen, 2019; Wei & Li, 2017). The term 'laboratory' for instance is used by learners to denote a room where they can test their unique ideas and interpretations, exploring the world around them. On the contrary the term 'practical work' can be used by learners to describe a context in which science learners engage in hands-on activities, such as observations and experiments, not solely for verification but also for discovery and knowledge acquisition. Laboratories stand out for their capacity to encourage inquiry and questioning, showcasing objects, ideas, processes, and experiments.

To this end, for the purposes of this study, practical work, as defined by the researchers, involves activities that engage learners in active learning aimed at fostering their curiosity and expanding their knowledge of scientific phenomena under investigation. The subsequent sections will explore the expectations of the Namibian science curriculum regarding practical work, the various types of practical work in the science classroom, the advantages of incorporating practical work in science education, and the challenges associated with implementing practical activities in science classrooms.

Expectations of the Science Practical work in the Namibian Curriculum Documents

In Namibia, the learner-centered approach is central to science education, as stipulated by the national curriculum and various syllabi that emphasize hands-on, practical activities in science classes. This educational directive is detailed in several key documents including the Physical Science Syllabus for Grades 8 and 9 (2015), the National Curriculum for Basic Education (MoEAC, [NCBE], 2018), and both the Chemistry and Physics Syllabi for Advanced Subsidiary and Ordinary Levels (2020; 2018). These documents collectively advocate for inquiry-based instruction and are critical in shaping the implementation strategies of the science curriculum, ensuring that practical work is integral to the teaching and learning process.

The junior secondary phase in Namibia aims to bridge the educational transition from primary to secondary, preparing learners for advanced scientific studies and real-world applications. The syllabi during this phase promote active learner engagement and underscore the necessity for teachers to adapt their instructional methods to meet the diverse needs of their students (Physical Science Syllabus Grades 8 & 9, 2015). Such adaptation is seen as crucial for fostering effective learning outcomes. Additionally, at the senior secondary level, subjects like Chemistry and Physics are presented with an experimental focus, which requires a robust assessment of learners' understanding and capabilities in practical work (Chemistry Syllabus Advanced Subsidiary Level Grade 12, 2020; Physics Syllabus Advanced Subsidiary Level Grade 12, 2020; Chemistry Syllabus Ordinary Level Grade 10-11, 2018; Physics Syllabus Ordinary Level Grade 10-11, 2018).

These assessments are categorized into three objectives: knowledge and understanding (objective A), application and problem-solving (objective B), and practical skills (objective C), the latter being the primary focus of this study. The emphasis is on ensuring that learners actively participate in experiments, with guidelines suggesting that students should engage in practical activities for at least 20% of their classroom time, excluding time spent on demonstrations (Physics Syllabus for Advanced Subsidiary Level Grade 12, 2020). This approach highlights the shift from passive learning to an active, inquiry-based educational experience, where students not only learn scientific theories but also apply these concepts through hands-on experiments.

Classification of Science Practical Work in the Science Classrooms

Numerous scholars in the field of science education have emphasised the significance of incorporating practical work within the science classroom, underscoring its pivotal role. Wei and Liu (2018) asserted that practical experimentation is closely intertwined with empowering learners to independently interpret scientific phenomena. Furthermore, Teo, Tan, Yan, Teo, and Yeo (2014) posited that engaging in hands-on practical activities can enhance and “facilitate the understanding of scientific concepts and the nature of science (NOS), provide opportunities to learn inquiry skills and problem solving, cultivate scientific habits of mind, and help students to develop a positive attitude towards science and the learning of science” (p. 551).

Various science scholars have explored the diverse aspects of science practical work, which encompasses activities such as experiments, investigations, discovery tasks, discovery approaches to teaching, and the process approach (Abrahams & Reiss, 2012; Jokiranta, 2014; Kidman, 2012; Motlhabane, 2013; Sedumedi, 2017; Twahirwa & Twizeyimana, 2020). Kidman (2012) classified seven distinct types and/or categories of science practical work employed by educators within science classrooms. These categories include demonstrations, laboratory experiments or closed inquiry, directed activity, undirected activity, skill development, guided inquiry, and open inquiry. Kidman’s research, which was conducted in Australia, suggested that each of these categories of science practical work fulfils a unique role in enhancing the learning experience for learners.

Benefits of Teaching Science through Practical Work

The primary purpose of incorporating practical work in science education is to equip young individuals with a robust conceptual understanding of scientific principles, enabling them to engage confidently and effectively in the contemporary world of the STEM era. In essence, this pedagogical approach emphasises the cultivation of scientific literacy among learners (Jagodziński & Wolski, 2015; Motlhabane, 2013; Twahirwa & Twizeyimana, 2020). Additionally, an essential objective of science education through practical work is to provide learners with concrete scientific foundations that will prepare them for future employment in science related fields (Motlhabane, 2013).

Practical work is proposed as a means to enhancing learners' appreciation of scientific knowledge and to cultivate their problem-solving skills, offering them insight into the scientific process through hands-on experimentation (Sshana & Abulibdeh, 2020). Accordingly, researchers support that learners should emulate scientific methodologies when tackling scientific problems (Sshana & Abulibdeh, 2020; Sofoklis et al., 2017).

The inclusion of science practical work in the learning process is justified by the objective of granting learners the autonomy to conduct their own scientific experiments and investigations, thereby facilitating the development of their scientific knowledge. In line with this, learners are perceived as active contributors to the construction of their scientific knowledge, (Bradley, 2021; Sshana & Abulibdeh, 2020; Twahirwa & Twizeyimana, 2020). In particular, Bradley's (2021) study highlights the various goals associated with teaching science in educational settings as outlined by a number of science experts.

In accordance with this, the Physics and Chemistry syllabi for the ordinary level have been designed to prepare learners for a special assessment form, denoted as paper 3, which evaluates their aptitude in experimental techniques, aligned with assessment objective C outlined in these syllabi. Accordingly, the official curriculum document underlines "the best way to prepare candidates for these papers is to integrate practical work fully into the course so that it becomes a normal part of your teaching" (Physics Syllabus Ordinary Level Grade 10 – 11, 2018, p. 45).

Factors Impeding the Implementation of Inquiry

Despite the recognized benefits of inquiry-based instruction in science education, its effective implementation often encounters significant barriers, as identified by numerous researchers (Capps et al., 2012; Baroudi & Rodjan Helder, 2021; Letina, 2021; Pesqueira, 2021). These barriers include teachers' epistemological beliefs about teaching and learning through inquiry, the adequacy of their content and pedagogical content knowledge, and the availability of suitable curriculum materials. Additional challenges such as learner resistance, the cost of materials, difficulties in addressing learners' misconceptions through inquiry, and classroom management issues further complicate the adoption of this pedagogical approach (van Driel et al., 2014; Crawford, 2014).

Ramnarain (2016) further explores the intrinsic and extrinsic factors affecting inquiry-based instruction in South Africa, revealing that science teachers often grapple with uncertainties related to various aspects of their professional knowledge. These include content knowledge, pedagogical knowledge, and pedagogical content knowledge, along with an understanding of their learners, the educational context, curriculum familiarity, and overall educational goals. Such uncertainties can significantly hinder teachers' confidence and effectiveness in implementing inquiry-based methods.

To foster a conducive environment for inquiry-based science instruction, it is crucial to address these challenges and facilitate a shift in both teachers' and learners' perspectives. This approach is vital for equipping 21st-century learners with the necessary scientific knowledge and skills, promoting a more interactive and engaging learning experience that can lead to deeper understanding and retention of scientific concepts (Baroudi & Rodjan Helder, 2021; Letina, 2021; Pesqueira, 2021). Emphasizing the benefits and overcoming the impediments to inquiry-based learning can help inculcate a robust scientific temperament in students across the globe.

Integrating Inquiry-Based Learning in Science Education

Despite the acknowledged benefits of inquiry-based learning in enhancing science education, significant challenges hinder its effective implementation. Research identifies several barriers, including teachers' epistemological beliefs, insufficient content knowledge, and lack of suitable curriculum materials. These obstacles are compounded by practical issues such as the cost of materials, learner resistance, difficulties in addressing misconceptions, and classroom management challenges (Capps et al., 2012; Baroudi & Rodjan Helder, 2021; Letina, 2021; Pesqueira, 2021; van Driel et al., 2014; Crawford, 2014). Additionally, intrinsic factors, such as uncertainties about professional knowledge and curriculum familiarity, affect teachers' confidence in implementing these methods (Ramnarain, 2016).

Addressing these challenges requires a concerted effort to shift both teachers' and learners' perspectives towards the value of inquiry-based methods. This educational approach is crucial for preparing 21st-century learners to thrive in a scientifically complex world, encouraging engagement and deeper understanding of scientific concepts. By fostering an environment that promotes active learning and critical thinking, inquiry-based science education can significantly enhance student outcomes and foster a robust scientific temperament, making it a critical area for educational development (Baroudi & Rodjan Helder, 2021; Letina, 2021; Pesqueira, 2021).

RESEARCH METHOD

This study adopted a sequential explanatory mixed methods approach to integrate quantitative and qualitative research techniques, which allowed for a comprehensive examination of the topic (Hitchcock & Onwuegbuzie, 2020; Tashakkori & Teddlie, 2021). Initially, quantitative data were collected and analyzed, followed by qualitative data to deepen the understanding of the findings. This methodology is particularly effective for integrating diverse perspectives and methodologies within a single study, thereby enhancing the depth and breadth of the research findings (Onwuegbuzie & Hitchcock, 2022).

The participants comprised teachers from all 14 educational regions of Namibia, primarily from rural areas, with most having over five years of experience in teaching science at secondary levels. Data collection involved a two-stage process: first, a questionnaire was administered to 133 science teachers to gather broad quantitative insights; then, in-depth qualitative data were collected through classroom observations and interviews with a select group of 10 teachers. This mixed approach facilitated a layered understanding of how teachers implement inquiry-based instruction in their classrooms. Data were analyzed using statistical tools for the quantitative portion and thematic analysis for the qualitative part, allowing for an integrated interpretation of how theoretical knowledge translates into practical application in diverse educational settings (Dawadi, 2020; Saldaña, 2015).

RESULTS AND DISCUSSION

This section presents the findings of the study, encompassing a comprehensive analysis of each research question. To enhance clarity and comprehension, relevant extracts are incorporated, and the data is systematically arranged within designated subsections. This structure is designed to facilitate the readers' grasp of the discourse and the explanation of the research findings.

Science Teachers' Conceptions of Inquiry-Based Instruction and Science Practical Work

Both, the questionnaire survey data, classroom observations, and teachers' interviews showed that teachers have strong conceptions about the enactment of inquiry-based instructions in their classrooms.

Data from Questionnaire Survey

Several criteria were employed to ascertain the views of teachers regarding inquiry-based instructional methods, as illustrated in Table 2. The participants' conceptualisations played a pivotal role in gauging their comprehension of inquiry-based instruction within the scope of the current study. Teachers were tasked with providing responses on a numerical scale ranging from 1 to 5, denoting degrees of agreement such that: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral/undecided, 4 = Agree, and 5 = Strongly agree.

Table 2: Science Teachers' Views of Inquiry-based Instruction

To determine the science Teachers' views of inquiry-based instructions	n	M	SD
Inquiry-based instruction is a learner-centred approach that invites learners to explore content by posing, investigating, and answering questions.	133	4.44	0.62
Through inquiry, learners are usually actively engaged in discovering information to support their investigations.	133	4.47	0.54
Inquiry-based instruction is a powerful way of learning science, regardless of a learner's language background	133	4.43	0.65
Inquiry-based instruction puts learners' questions at the centre of the science curriculum.	133	4.34	0.64
Inquiry-based instruction places as much emphasis on research skills as it does on knowledge and understanding of the science content.	133	4.32	0.67
Within inquiry-based instruction, teachers usually commit to providing rich experiences that provoke learners' thinking and curiosity to conduct their own experiments.	133	4.46	0.65
Using an inquiry-based approach allows learners to draw connections between scientific content and their own lives.	133	4.45	0.62
In an inquiry-based classroom, learners are given opportunities to take ownership of their own learning.	133	4.47	0.58
Inquiry-based teaching inspires learners to learn more and to learn more thoroughly.	133	4.32	0.70
Inquiry-based teaching methods can benefit both culturally and linguistically diverse learners and learners with special needs and learning difficulties.	133	4.28	0.72
An inquiry-based approach to teaching can increase learners' achievement and narrow the gap between high-and low-achieving learners.	133	4.26	0.68
When used in place of a traditional textbook approach, an inquiry-based approach can yield significantly higher achievement for learners with learning difficulties.	133	4.28	0.54
Learners develop a sense of belonging through inquiry-based instructions as they allow them to participate in activities such as group projects, science projects, and unique exercises designed for specific groups of learners.	133	4.46	0.58
Inquiry-based instruction helps learners focus on open questions or problems to use evidence-based reasoning, creative thinking, and problem-solving to form a conclusion they can defend.	133	4.41	0.49
Inquiry-based learning enables teachers to help learners get from the curiosity stage into critical thinking and deeper levels of understanding of science concepts.	133	4.44	0.54

In an inquiry-based classroom, teachers are usually viewed as not doing anything, as learners usually formulate questions and seek out answers.	133	3.93	1.08
TOTAL	133	4.36	0.64

The tabulated results, presented in Table 2, revealed an overall mean score of 4.36, accompanied by a reasonably consistent standard deviation of 0.64, concerning the objectives relating to teachers' perspectives on inquiry-based instruction. This outcome suggests that a substantial proportion of teachers hold multifaceted perspectives on inquiry-based instruction, considering them integral to the implementation of science practical work in Namibian science classrooms. Subsequently, based on these findings, it is agreeably emphasised that a majority of teachers espouse robust views regarding the significance of inquiry-based instruction in the teaching pedagogy of science.

With regards to the enactment of science practical work, teachers appear to have informed views, attitudes, and beliefs (conceptions) in terms of their practices about inquiry-based instructions. Table 3, shows the results obtained from the questionnaire. Table 3., depicts the data analysis of data regarding teachers' practices, views, attitudes, and beliefs of using inquiry-based instructions in the teaching of science practical work.

Table 3. Teachers' Classroom Practices in Enacting Inquiry-based Instruction in Science Practical Work

	n	M	SD
Inquiry-based science instructions challenges learners' thinking by engaging them in scientifically oriented questions in which they learn to prioritize evidence, evaluate explanations, and in light of alternative explanations, and communicate and justify their decisions.	133	4.37	0.58
Using inquiry-based instructions enables learners to develop the dispositions needed to promote and justify their decisions.	133	4.33	0.57
Inquiry-based learning improves learners' understanding of scientific concepts and increases their interest in the subject.	133	4.40	0.62
When learners are provided with autonomy of scientific inquiry, it enables them to conduct their own practical work.	133	4.32	0.63
By allowing learners to explore topics on their own and create their own learning process, inquiry-based learning instils fun and engagement in the practical work of science.	133	4.38	0.66
When learners have control over their learning process, they become more engaged, which contributes to the development of a passion for exploration and learning at a higher level and the development of their own practical work.	133	4.41	0.68
Using inquiry-based instructions in science practical work helps learners improve their understanding, develop their problem-solving skills, and understand the nature of science.	133	4.35	0.68
Inquiry-based instructions encourage learners to make links between their theoretical and practical knowledge.	133	4.42	0.65
Inquiry-based instruction supports science practical work by keeping learners focused on the task while they are engaged in hands-on activities.	133	4.33	0.65
Inquiry-based instruction prepares learners' minds for science practical work by providing background information on what they are investigating.	133	4.37	0.65
As a teacher is viewed as a facilitator in an inquiry-based classroom, learners usually have full autonomy in carrying out their science practical work.	133	4.23	0.76
Inquiry-based learning as a stepping stone towards practical work provides opportunity for experimental learning, in which a learner can prove a scientific theory rather than memorizing facts.	133	4.40	0.65
TOTAL	133	4.36	0.65

Based on this empirical data from the participants, the results gave an impression that inquiry-based learning adds value to the experimental learning that classify learners not as a bank of information, but rather as practical players in the inquiry-based instruction. Furthermore, these results are notably indicative that teachers' practices, views, attitudes and beliefs of using inquiry-based instructions in the teaching of science practical work are positive as a total average strong mean score of 4.36, and a notably constant standard deviation of 0.65 were scored.

Data from Classroom Observations

During the process of classroom observation, each of the 10 teacher's instructional practice was subject to analysis while enacting a practical activity or experiment. The diversity in the nature of practical activities among teachers became apparent, outlined by their preferences, encompassing both teacher-guided and learner-initiated modes (referred to as learner-led practical activities). The ensuing analysis focused on distinct behavioural indicators differentiated throughout the observational sessions, namely: the degree of learners' engagement in the assigned task, instances of off-task behaviour among learners, disruptive conduct exhibited by learners during practical tasks, and positive manifestations of behaviour, such as learners assisting peers or the teacher in handling experimental apparatus.

Table 4., shows the summary of teachers where the classroom observations were conducted in terms of the subjects in which teachers were observed and the grade classes they taught.

Table 4. Teachers' Observation Schedule

Teacher's Name	Subject Observed	Grade
Teacher Nangula	Physical Science	9B
Teacher Simasiku	Physical Science	8C
Teacher Nanub	Chemistry	10A
Teacher Kamina	Physics	11B
Teacher Maluleke	Physical Science	11A
Teacher Ingrid	Chemistry	11D
Teacher Beaullah	Physics	9C
Teacher Fritz	Chemistry	11B
Teacher Tangeni	Physics	11A
Teacher Manyando	Physics	10B

In observing classroom dynamics across various settings, distinct instructional strategies were evident, shaped largely by the interaction between teachers and learners during science practical activities. For example, in Teacher Nangula's class, despite a class size exceeding the ideal teacher-learner ratio, the lesson was characterized by a teacher-led practical activity where learners actively participated, albeit with the teacher central to the facilitation process. This observation suggests a potential for enhancing independent inquiry among students if more opportunities are provided for them to conduct science practical work autonomously, potentially leading to greater engagement and confidence in scientific exploration.

In contrast, Teacher Nanub's approach demonstrated a more learner-driven method, where students independently formulated questions and hypotheses during a practical on carbon dioxide production. This method aligns with inquiry-based educational principles, fostering active learner participation and collaboration in the scientific process. The effectiveness of such an approach was apparent in learners' enjoyment and confidence in science, which could be crucial in addressing practical examination questions effectively.

Observations in Teacher Maluleke's and Beaullah's classrooms highlighted challenges and successes in implementing inquiry-based learning. Maluleke faced obstacles due to class size, space constraints, and limited resources, which affected the assignment of individual tasks, pushing learners towards a collaborative approach. Conversely, in Beaullah's class, inquiry-based instruction notably enhanced learners' curiosity and engagement, particularly during experiments like pH testing, where learners actively questioned and analyzed the results, demonstrating the core benefits of this educational approach.

These classroom insights reveal that while teachers strive to implement learner-centered and inquiry-based methodologies, several challenges persist, including resource limitations and class size constraints. Yet, the observed learner engagement and teacher facilitation indicate a strong inclination towards hands-on, inquiry-driven learning experiences, underscoring the need for supportive educational policies and resources to overcome these barriers and fully realize the potential of practical science work in fostering a deep understanding and curiosity in scientific subjects.

Data from Interviews

Teachers were interviewed to provide insights into their instructional approaches aligning with the advocacy of the science curriculum outlined by the NCBE and the National Subject Policy for Physical Science. This study focused on Grades 8 and 9 Physical Science and Physics or Chemistry for Grades 11 to 11 in Namibian schools. The interview data underwent thematic analysis, with themes developed following Sundler et al.'s (2019) framework. The process involved familiarisation with the data, extracting meaning, and organising information to generate themes. This approach facilitated a comprehensive understanding of science teaching practices among Namibian teachers.

An essential aspect in the present implementation of science practical work in Namibian schools is the understanding of inquiry-based instruction by teachers. In soliciting their perspectives, participants were prompted to explain their understanding of this instructional approach during the interviews, yielding diverse responses from the teacher cohort. Some of the teachers have this to say regarding their understanding of science practical work using inquiry-based instruction:

> *When it comes to enquiry-based instruction it has to do with learners' and strategies,*
> *where learners come up with their own constructive ways of learning during the teaching process (Teacher Kamina).*
> *The strategy that I normally employ in my class is just for the learner to carry out them (Teacher Maluleke)*
> *own experiment so that they know exactly what they want to find out in that practical*
> *(Teacher Ingrid).*
> *What I understand by the concept of inquiry-based instruction is the ability for learners to direct their own learning by being involved in their learning through asking questions, that direct the teaching of the content, that direct the teaching strategies of the teacher (Teacher Nanub).*
> *I believe it's a way of involving learners in what they are learning to take over the learning into their hands and they carry out investigations and then they come to results through the guidance of the teacher (Teacher Nangula).*

Based on insights gathered from interviews with teachers, it became evident that teachers recognise the pivotal role of learners assuming responsibility for their learning in science within an inquiry-based instructional framework. Teachers emphasise the shift from a traditional model where learners passively receive information from the authoritative teacher to a dynamic paradigm where learners actively engage in their learning process.

The consensus among teachers is that inquiry-based instruction serves as a vehicle for fostering learner autonomy, and empowering them to take charge of their educational journey. This instructional approach, as articulated by teachers during interviews, entails learners formulating questions and independently conducting scientific inquiries. The teachers generally highlight the importance of guiding and directing the learning trajectory, refuting the notion that inquiry-based education is synonymous with unfettered learner autonomy. Instead, they advocate for a balanced approach, incorporating structured guidance to facilitate active learning, critical thinking, and overall educational autonomy.

To ascertain teachers' perspectives on the implementation of inquiry-based instruction as a pedagogical approach, the first author conducted interviews wherein participants were asked to give their opinions on the assertion that "inquiry-based instruction as a teaching strategy is currently preferred when enacting science practical work. What do you make of this statement?" The objective was to gain insights into teachers' perceptions of the extent to which the adoption of inquiry-based instruction influences their instructional methodologies. The extracts hereunder outline teachers' responses to the statement:

> *Inquiry-based instruction is an ideal teaching strategy when teaching science practical work because; it helps learners to develop science techniques and to master the science technics. It allows learners to develop critical thinking skills; it also allows learners to just develop the scientific phenomena as students and as science professionals in the future (Teacher Simasiku).*
>
> *I believe this teaching strategy it is preferred and I think, it is preferred with a reason, reason being as we have discussed earlier, inquiry based-instructions they are much more practical right, and they allow the learner to experience the process for themselves which is much better than just hiding information, because in that way there is no much learning being done more especially with science practical one, science practical work is all about being hands-on, it's all about working with objects, it's all about conducting experiment. Inquiry based instruction allows learners or gives learners the autonomy to go out there and do things for themselves and conduct experiments for themselves and that works hand in hand with science practical work because they are the ones who supposed to do it and they are the ones who supposed to learn from it (Teacher Nangula).*
>
> *Maybe is preferred because it gives good results, also learners learn a lot more on their own given instructions (Teacher Tangeni).*

According to teacher responses, the implementation of inquiry-based instruction facilitates self-regulated learning in learners by stimulating their curiosity and equipping them with the necessary skills to comprehend the manipulation of objects. This pedagogical approach fosters learner autonomy in object manipulation, diminishing the reliance on teacher support. Consequently, it is posited that learners, under this framework, are capable of independently engaging in activities and achieving desired outcomes.

Factors are Informing Science Teachers' Usage and Enactment of Inquiry- Based Instruction

Inquiry-based instruction significantly shapes the teaching strategies of science educators in Namibia, with various factors influencing their approach to practical science work. Teachers in the study, such as Teacher Manyando, who noted, "The way I was taught in school as a learner and the way I was trained as a teacher during my teacher training," and Teacher Fritz, who emphasized, "My own understanding of what inquiry-based instruction is and its relevance and relatedness to practical work," highlight the personal and professional influences on their pedagogical choices. Additional factors cited by teachers include their own attitudes towards science, the curricular time allocated for science, and the resources available for conducting practical work, as noted by Teacher Beaullah: "Resources, apparatus, and equipment to carry out practical science work is what inform my teaching practices."

These personal and environmental factors collectively affect the effectiveness of inquiry-based instruction in the classroom. The study revealed strong teacher awareness of the learner-centered approach and the principles of inquiry-based learning. Teachers recognize the role of inquiry as a facilitator for learners to actively explore and comprehend content through hands-on activities. This educational approach is supported by the structure of the Namibian science syllabi and the national subject policy, which advocate for learner-centered education across various subjects and grade levels (MoEAC [NCBE], 2018).

The impact of inquiry-based learning extends beyond classroom engagement, influencing learners' academic performance and conceptual understanding of science. Teachers who grasp the full potential of inquiry-based methods tend to integrate these strategies effectively, thereby enhancing the overall learning experience. This approach not only aids in the acquisition of scientific knowledge but also fosters critical thinking and problem-solving skills among students. Furthermore, as the study suggests, "Teachers employing inquiry-based pedagogy contribute to the development of critical thinking, cooperative and collaborative skills, information analysis, and the cultivation of scientific curiosity in learners."

Despite the recognized benefits, implementing inquiry-based instruction faces challenges, including limited resources and insufficient professional development for teachers. Addressing these barriers is crucial for maximizing the effectiveness of inquiry-based methods in science education. By enhancing support structures and resources, Namibia can further capitalize on the benefits of inquiry-based learning, fostering a more engaged and scientifically literate student population.

CONCLUSION

Teachers in Namibia emphasised the significance of inquiry-based instruction as a pivotal element within the learner-centred approach, a contemporary teaching method reflected in science education curriculum documents. Particularly, the Physical Science Syllabus for Grades 8 & 9 (2015), Chemistry Syllabus for Advanced Subsidiary Level Grade 12 (2020), Physics Syllabus for Advanced Subsidiary Level Grade 12 (2020), Chemistry Syllabus for Ordinary Level Grade 10–11 (2018), Physics Syllabus for Ordinary Level Grade 10–11 (2018), and the Ministry of Education's (MoE) guidelines from 2006 all incorporate this approach.

While the questionnaire survey results indicated teachers' recognition of inquiry-based instruction's importance in science classrooms, a more intricate viewpoint emerges from classroom observations and interviews. Despite teachers' conceptual understanding of inquiry-based instruction, various impediments hinder its effective implementation, including resource unavailability, teachers' insufficient skills, behavioural challenges among both teachers and learners, and the constraints imposed by large class sizes. Consequently, despite teachers' comprehension of the inquiry-based approach, practical challenges impede its seamless integration into science education.

REFERENCES

Abrahams, I., & Reiss, M. J. (2012). Practical work: Its effectiveness in primary and secondary schools in England. *Journal of Research in Science Teaching, 49*(8), 1035–1055. https://doi.org/10.1002/tea.21036

Asheela, E. N. (2017). *An intervention on how using easily accessible resources to carry out hands-on practical activities in science influences science teachers' conceptual development and dispositions* [Unpublished Master's thesis]. Rhodes University, Grahamstown.

Asheela, E., Mlungisi Ngcoza, K., & Sewry, J. (2020). The use of easily accessible resources during hands-on practical activities in rural under-resourced Namibian schools. In *School Science Practical Work in Africa* (1st ed., pp. 14–31). Routledge. https://doi.org/10.4324/9780429260650-2

Bandura, A. (2014). Social cognitive theory of moral thought and action. In *Handbook of moral behavior and development* (1st ed., pp. 69-128). Psychology press.

Baptista, G. C. S., & Molina-Andrade, A. (2021). Science teachers' conceptions about the importance of teaching and how to teach Western science to students from traditional communities. *Human Arenas, 6*(4), 1-28. https://doi.org/10.1007/s42087-021-00257-4

Baroudi, S., & Rodjan Helder, M. (2021). Behind the scenes: teachers' perspectives on factors affecting the implementation of inquiry-based science instruction. *Research in Science and Technological Education, 39*(1), 68–89. https://doi.org/10.1080/02635143.2019.1651259

Bradley, J. (2021). Achieving the Aims of Practical Work with Microchemistry. In *Research in Chemistry Education* (6th ed., pp. 23–30). https://doi.org/10.1007/978-3-030-59882-2_2.

Bueno, O. (2013). Perception and conception: Shaping human minds. *Biosemiotics, 6*(3), 323–336. https://doi.org/10.1007/s12304-013-9170-z

Capps, D. K., Crawford, B. A., & Constas, M. A. (2012). A Review of Empirical Literature on Inquiry Professional Development: Alignment with Best Practices and a Critique of the Findings. *Journal of Science Teacher Education, 23*(3), 291–318. https://doi.org/10.1007/s10972-012-9275-2

Caravias, V. (2018). Teachers' conceptions and approaches to blended learning: A literature review. In *Online Course Management: Concepts, Methodologies, Tools, and Applications* (1st ed., pp. 912-934). IGI Global. http://doi.org/ 10.4018/978-1-5225-5472-1.ch046

Chan, K. K. H., & Hume, A. (2019). Towards a consensus model: Literature review of how science teachers' pedagogical content knowledge is investigated in empirical studies. In *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (1st ed., pp. 3–76). Springer. https://doi.org/10.1007/978-981-13-5898-2_1

Clarke, V., Braun, V., & Hayfield, N. (2015). *Thematic analysis. Qualitative psychology: A practical guide to research methods.* London : SAGE. SAGE Publications Ltd.

Cobern, W. W., Schuster, D., Adams, B., Skjold, B. A., Muğaloğlu, E. Z., Bentz, A., & Sparks, K. (2014). Pedagogy of science teaching tests: Formative assessments of science teaching orientations. *International Journal of Science Education, 36*(13), 2265-2288.

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In *Handbook of Research on Science Education* (2nd ed., pp. 529-556). Routledge.

Dawadi, S. (2020). Thematic analysis approach: A step by step guide for ELT research practitioners. *Journal of NELTA, 25*(1-2), 62-71.

Demirdöğen, B., & Uzuntiryaki-Kondakçı, E. (2016). Closing the gap between beliefs and practice: Change of pre-service chemistry teachers' orientations during a PCK-based NOS course. *Chemistry Education Research and Practice, 17*(4), 818-841.

Dewey, J. (1929). The sphere of application of the excluded middle. *The Journal of philosophy, 26*(26), 701-705.

Gess-Newsome, J. (2015). A Model Of Teacher Professional Knowledge And Skill Including Pck : Results of the thinking from the PCK Summit. In *Innovations in Science Teacher Education* (1st ed., pp. 28–42). Routledge. https://doi.org/10.4324/9781315735665-4

Hitchcock, J. H., & Onwuegbuzie, A. J. (2020). Developing mixed methods crossover analysis approaches. *Journal of Mixed Methods Research, 14*(1), 63-83.

Hofstein, A., Kipnis, M., & Abrahams, I. (2013). How to learn in and from the chemistry laboratory. In *Teaching chemistry–A study book* (pp. 153-182). Brill Sense.

Holt, E. B., & Brown, H. C. (1931). *Animal drive and the learning process, an essay toward radical empiricism*. New York: H. Holt and Company.

Ireland, J. E., Watters, J. J., Brownlee, J., & Lupton, M. (2012). Elementary Teacher's Conceptions of Inquiry Teaching: Messages for Teacher Development. *Journal of Science Teacher Education, 23*(2), 159–175. https://doi.org/10.1007/s10972-011 9251-2

Jagodziński, P., & Wolski, R. (2015). Assessment of Application Technology of Natural User Interfaces in the Creation of a Virtual Chemical Laboratory. *Journal of Science Education and Technology, 24(*1), 16–28. https://doi.org/10.1007/s10956-014-9517-5

Jokiranta, K. (2014). *The Effectiveness of Practical Work in Science Education*. Jyväskylän yliopisto : University of Jyväskylä.

Keller, M. M., Neumann, K., & Fischer, H. E. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching, 54*(5), 586–614.https://doi.org/10.1002/tea.21378

Kidman, G. (2012). Australia at the crossroads: A review of school science practical work. *Eurasia Journal of Mathematics, Science and Technology Education, 8*(1), 35–47. https://doi.org/10.12973/eurasia.2012.815a

Lee, M & Sulaiman, F. (2018). The Effectiveness of Practical Work in Physics To Improve Students' Academic Performances. *People: International Journal of Social Sciences, 3*(3), 1404-1419.

Linn, M. C., Bell, P., & Davis, E. A. (2004). Specific design principles: Elaborating the scaffolded knowledge integration framework. In M. C. Linn, E. A. Davis, & P. Bell (Eds.), *Internet environments for science education* (pp. 315–339). Lawrence Erlbaum Associates Publishers.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome and N. G. Lederman (Eds.), *PCK and Science Education* (pp. 95-132). Springer, Dordrecht.

Maseko, B., & Khoza, H. C. (2021). Exploring the influence of science teaching orientations on teacher professional knowledge domains: a case of five Malawian teachers. *Eurasia Journal of Mathematics, Science and Technology Education, 17(*12), 1-17. https://doi.org/10.29333/ejmste/11333

Matos, D. A. S., & Jardilino, J. R. L. (2016). Os conceitos de concepção, percepção, representação e crença no campo educacional: similaridades, diferenças e implicações para a pesquisa. *Educação Formação, 1*(3), 20–31. https://doi.org/10.25053/edufor.v1i3.1893

Ministry of Education, Arts and Culture. (2015). *Physical Science Syllabus Grades 8 and 9*. Okahandja: NIED.

Ministry of Education, Arts and Culture. (2020). *Chemistry Syllabus, Advanced Subsidiary Level*. Okahandja: NIED.

Ministry of Education, Arts and Culture. (2020*). Physics Syllabus, Advanced Subsidiary Level*. Okahandja: NIED.

Ministry of Education, Arts and Culture. (2020). *National Subject Policy Guide for Physical Science Grades 8 - 9, Physics and Chemistry Grade 10 - 11*. Okahandja: NIED.

Ministry of Education, Arts and Culture. (2018). *National Curriculum for Basic Education (NCBE)*. Okahandja: NIED.

Ministry of Education, Arts and Culture. (2018). *Physics Syllabus Ordinary Level Grade 10 – 11*. Okahandja: NIED.

Ministry of Education, Arts and Culture. (2018). *Chemistry Syllabus Ordinary Level Grade 10–11*. Okahandja: NIED.

Mohammed, S. M., & Amponsah, K. D. (2021). Teachers' and educational administrators' conceptions of inquiry: Do they promote or constrain inquiry-based science teaching in junior high schools*?. Journal of Curriculum and Teaching, 10*(3), 58–71. https://doi.org/10.5430/jct.v10n3p58

Mokiwa, H. O. (2014). Exploring the teaching of Physical Science through inquiry. *International Journal of Educational Sciences, 7*(1), 21-27.

Mokiwa, H. O., & Nkopodi, N. (2014). Inquiry-based teaching in physical science: Teachers' instructional practices and conceptions. *Mediterranean Journal of Social Sciences, 5*(23), 1074–1082. https://doi.org/10.5901/mjss.2014.v5n23p1074

Motlhabane, A. (2013). The voice of the voiceless: Reflections on science practical work in rural disadvantaged schools. *Mediterranean Journal of Social Sciences, 4*(14), 165–173. https://doi.org/10.5901/mjss.2013.v4n14p165

Muyoyeta, N. K. (2018). *Factors affecting Grade 12 learners' academic performance in the Namibia Senior Secondary Certificate ordinary level Biology in the Khomas educational region* [Masters Dissertation].University of Namibia.

National Research Council. (2012). *A framework for K – 12 science Curriculum practices crosscutting concepts and ideas*. Washington, DC: American Association for Advancement of Science.

National Research Council. (2013). *Next generation science standard: for states, by states*. Washington DC: The National Academies Press.

Nilsson, P., & Loughran, J. (2012). Exploring the Development of Pre-Service Science Elementary Teachers' Pedagogical Content Knowledge. *Journal of Science Teacher Education, 23*(7), 699–721. https://doi.org/10.1007/s10972-011-9239-y

Onwuegbuzie, A. J., & Hitchcock, J. H. (2022). Towards a Comprehensive Meta-Framework for Full Integration in Mixed Methods Research. In *The Routledge Handbook for Advancing Integration in Mixed Methods Research* (pp. 565-606). Routledge.

Ramnarain, U. (2016). Understanding the influence of intrinsic and extrinsic factors on inquiry-based science education at township schools in South Africa. *Journal of Research in Science Teaching, 53*(4), 598-619.

Ramnarain, U. (2021). *School Science Practical Work in Africa; Experiences and Challenges; First Edition*. Boca Raton: Routledge.

Ramnarain, U., & Hlatswayo, M. (2018). Teacher beliefs and attitudes about inquiry-based learning in a rural school district in South Africa. *South African Journal of Education, 38*(1).

Saldaña, J. (2015). *The coding manual for qualitative researchers*. London: Sage.

Sedumedi, T. D. T. (2017). Practical work activities as a method of assessing learning in chemistry teaching. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(6), 1765–1784. https://doi.org/10.12973/eurasia.2017.00697a

Shivolo, T. (2018). *Teachers' Pedagogical Orientations in grade 8 Teacher-orchestrated Chemistry Practical Demonstrations: A focus on Oshikoto Region, Namibia* (Master's Dissertation). Johannesburg: University of Johannesburg. Retrieved November 11 2023, from https://hdl.handle.net/10210/402293.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1–22.

Sofoklis, S., Rodger W., B., & Bogner, F. X. (2017). PATHWAYS – A Case of Large-Scale Implementation of Evidence-Based Practice in Scientific Inquiry-Based Science Education. *International Journal of Higher Education, 6*(2), 8. https://doi.org/10.5430/ijhe.v6n2p8

Sshana, Z., & Abulibdeh, E. S. (2020). Science practical work and its impact on students' science achievement. *Journal of Technology and Science Education, 10*(2), 199–215. https://doi.org/10.3926/JOTSE.888

Sundler, A. J., Lindberg, E., Nilsson, C., & Palmér, L. (2019). Qualitative thematic analysis based on descriptive phenomenology. *Nursing open, 6*(3), 733-739.

Tashakkori, A., & Teddlie, C. (2021). *Sage handbook of mixed methods in social & behavioral research*. SAGE publications.

Taylor, D. L., & Booth, S. (2015). Secondary physical science teachers' conceptions of science teaching in a context of change. *International Journal of Science Education, 37*(8), 1299-1320.

Teo, T. W., Tan, K. C. D., Yan, Y. K., Teo, Y. C., & Yeo, L. W. (2014). How flip teaching supports undergraduate chemistry laboratory learning. *Chemistry Education Research and Practice, 15*(4), 550-567.

Twahirwa, J., & Twizeyimana, E. (2020). Effectiveness of Practical Work in Physics on Academic Performance among Learners at the selected secondary school in Rwanda. *African Journal of*

Educational Studies in Mathematics and Sciences, 16(2), 97–108. https://doi.org/10.4314/ajesms.v16i2.7

van Driel, J. H., Berry, A., & Meirink, J. (2014). Research on science teacher knowledge. In *Handbook of Research on Science Education* (pp. 862-884). Abingdon, UK: Routledge.

Wei, B., & Li, X. (2017). Exploring science teachers' perceptions of experimentation: implications for restructuring school practical work. *International Journal of Science Education, 39*(13), 1775–1794. https://doi.org/10.1080/09500693.2017.1351650

Wei, B., & Liu, H. (2018). An Experienced Chemistry Teacher's Practical Knowledge of Teaching with Practical Work: The PCK Perspective. *Chemistry Education Research and Practice, 19*(2), 452-462.

Wei, B., Chen, S., & Chen, B. (2019). An Investigation of Sources of Science Teachers' Practical Knowledge of Teaching with Practical Work. *International Journal of Science and Mathematics Education, 17*(4), 723–738. https://doi.org/10.1007/s10763-018-9886-y

Wellington, J., & Ireson, G. (2012). Science learning, science teaching. Abingdon, UK: Routledge.

Yung, B. H. W., Zhu, Y., Wong, S. L., Cheng, M. W., & Lo, F. Y. (2013). Teachers' and students' conceptions of good science teaching. *International Journal of Science Education, 35*(14), 2435-2461.