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The paradigm shift in science education: Namibian science teachers' perceptions and experiences with inquiry-based instruction

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ABSTRACT

This study explored Namibian science teachers' perceptions of and approaches towards integrating inquiry-based instruction in science education. A survey questionnaire with 133 participants determined their opinions, attitudes, and beliefs revealing a strong preference for inquiry-based methods, with an average rating of 4.36 on a five-point Likert scale. Teachers emphasised its effectiveness in engaging learners, fostering critical thinking, and connecting scientific principles to real-world scenarios. The study examines key factors that impact the enactment of inquiry-based instruction, including teachers' prior experiences, understanding of inquiry, and philosophical viewpoints on the nature of science. The findings from this study showed that the allocation of time in the curriculum, the behaviour of learners, and the availability of resources were recognised as important factors impeding the successful implementation of inquiry-based instruction. The study suggests tailored professional development to address challenges and enhance teachers' ability to embrace inquiry-based practices effectively. These insights contribute to understanding determinants influencing innovative pedagogical approaches in Namibian science classrooms, informing educational policies and initiatives for teacher training in the country.

Keywords: paradigm shift, inquiry-based instruction, Namibian science teachers, science education, teachers' perceptions, teachers' experiences

INTRODUCTION

Namibia, situated in the southwestern region of Africa, has demonstrated a steadfast dedication to improving its education system in order to align with the requirements of an interconnected and technologically advanced globe (Kambeyo, 2018). The Namibian Ministry of Education, Arts and Culture (MoEAC) has shown a keen interest in adopting inquiry-based instruction to foster the development of learners' scientific literacy and critical thinking abilities (Katukula, 2018). Nevertheless, the effective implementation of inquiry-based instruction is mostly dependent on teachers, as they play a pivotal role in facilitating this pedagogy in the classroom. Therefore, it is imperative to examine the perceptions of Namibian science teachers about inquiry-based education, the factors that impact their adoption of this approach, and the extent to which their opinions coincide with the objectives set by MoEAC.

The importance of science education in determining a nation's future lies in its ability to cultivate critical thinking, problem-solving abilities, and a scientific attitude among its populace (Mwazi, 2022). In recent years, there has been an increasing acknowledgement of the necessity for a fundamental change in science education, shifting away from conventional and/or traditional teacher-centered systems towards a more learner-centered and inquiry-driven method (Logeswaran et al., 2021; Nair, 2020). This transition corresponds to the changing expectations of the 21st century, prioritizing the development of abilities that extend beyond mere memorization (Tan, 2021).

Namibia, like numerous other nations, is experiencing significant changes in its educational sector to address the demands of a quickly progressing global environment (Jellenz et al., 2020; Paranad et al., 2023). The field of science education is currently leading the way in implementing these reforms, with an emphasis on actively involving learners in ways that improve their conceptualization of scientific principles (Jimenez-Liso et al., 2021; Rodriguez & Morrison, 2019). An increasingly prominent technique is the use of inquiry-based instruction, which involves learners actively engaging in the learning process by exploring, experimenting, and making discoveries (Cairns & Areepattamannil, 2019; Chu et al., 2021; Gholam, 2019; Husni, 2020; Yildiz-Feyzioglu & Demirci, 2021).

This article originates from the Author's doctoral work.

Science education in Namibia has undergone a significant change in recent years, shifting from a traditional teacher-centered approach to a more learner-centered and engaging pedagogies (Mwazi, 2022; Potokri & Mwelitondola, 2022; Shatumbu, 2019). This change is particularly evident in science education, as highlighted by a studies conducted by Sheehama (2018). An example of a modern teaching method that is becoming increasingly popular in science education is inquiry-based instruction. Academic scholars have struggled to define and understand inquiry, leading to confusion and varied descriptions of the concept, this has resulted to its description as 'elastic' (Capps, 2012). Thus, inquiry-based instruction has become widely adopted in science classrooms worldwide as the leading contemporary teaching method (Cairns & Areepattamannil, 2019; Chu et al., 2021; Oliver et al., 2021). It enhances long-lasting acquisition of knowledge and skills among learners, making it a recognized pedagogy for the 21st century.

Inquiry-based instruction is a pedagogical approach that focuses on fostering curiosity, analytical thinking, and active participation among learners, placing them at the core of the learning experience (Abdurrahman et al., 2019; Archer-Kuhn & MacKinnon, 2020; Chu et al., 2021; Shikongo, 2022). This strategy promotes learner engagement by fostering inquiry, facilitating topic exploration, and facilitating the construction of knowledge through experiential activities and investigation (Archer-Kuhn, & MacKinnon, 2020). Understanding teachers' perceptions and implementation of inquiry-based instruction is crucial as education systems globally strive to adapt to the evolving demands of the 21st century teaching approaches. Multiple studies have repeatedly demonstrated that inquiry-based learning has a positive impact on learners' comprehension of scientific concepts and also fosters the growth of critical thinking, problem-solving, and communication abilities (Shinana et al., 2021). As a result, teachers strive to foster a more profound and long-lasting comprehension of scientific concepts by actively engaging learners in the process of scientific inquiry.

The adoption of inquiry-based learning is founded on educational ideas like constructivism, which suggests that learners construct their understanding via active engagement and reflection (Siseho, 2018; Xu & Shi, 2018). In the domain of science education, this entails offering learners the chance to investigate real-life issues, develop hypotheses, carry out experiments, and derive findings - reflecting the methodologies employed by experts in the field (Ntinda et al., 2021).

Although the advantages of inquiry-based instruction are well recognized, the effective accomplishment of these methods relies heavily on teachers' opinions and experiences. Teachers play a vital role in the classroom by acting as primary facilitators of knowledge, helping learners through the process of inquiry. Gaining insight into the perceptions and experiences of Namibian science teachers on the transition in teaching methodologies is essential for assessing the efficacy and durability of the paradigm change in science education.

The study was guided by the following main research question:

1. What are the teachers' conceptions of teaching science practical work through inquiry-based instruction in Namibian schools?

Based on the main research question, the following sub-research questions were set:

a. What are the science teachers' views of inquiry-based instructions?
b. How do science teachers' views of inquiry-based instructions facilitate science practical work?
c. What factors are affecting science teachers' usage and enactment of inquiry- based instructions in their science practical work?

LITERATURE REVIEW

Inquiry-Based Learning & Learner Outcomes

Extensive evidence highlights the beneficial effects of inquiry-based learning on learner outcomes (Aditomo & Klieme, 2020; Baroudi & Rodjan Helder, 2021; Gholam, 2019; Hendriarto et al., 2021; Yildiz-Feyzioglu & Demirci, 2021). Research repeatedly demonstrate that learners experience enhanced comprehension of scientific principles, improved critical thinking abilities, and increased levels of engagement through inquiry-based approaches to teaching and learning (Bui & Khuu, 2020; Cairns & Areepattamannil, 2019; Chu et al., 2021; Faridi et al., 2021; Jeon et al., 2021; Katan & Baarts, 2023; Mulyeni et al., 2019; Oktaviah et al., 2021; Saputro et al., 2019; Suwono et al., 2021; Tan, 2021; Tan et al., 2020). Nevertheless, although these studies offer useful insights, they frequently neglect to prioritize the teacher's viewpoint. The present study seeks to fill this gap by focusing on science teachers in Namibia, investigating their perspectives and encounters with inquiry-based teaching methods.

Several scholars have outlined that the use of inquiry-based teaching approaches in science offers a detailed analysis of the lasting impact of inquiry-based education on learner achievement (Borovay et al., 2019; Cairns & Areepattamannil, 2019; Jerrim et al., 2022). The research reveals consistent and favorable results in terms of both subject knowledge and the development of critical thinking abilities. This study highlights the significance of continuous exposure to inquiry-based instruction in order to maximize the learning advantages gained by learners. The focus on long-term impact enhances learners understanding of the increasing advantages of inquiry-based learning throughout a learner's educational trajectory.

Furthermore, many research studies also confirms the existence of a favorable relationship between inquiry-based learning and learner academic performance (Cairns, 2019; Cairns & Areepattamannil, 2019; Gajic et al., 2021; Kang, 2022). Meta-analysis studies conducted by some researchers also provide evidence for the notion that inquiry-based methods improve learners' conceptual knowledge (Sugano & Nabua, 2020; Yang et al., 2020). Additionally, it reveals the potential discrepancies in effectiveness among various science fields. Having a refined perspective is essential for teachers and policymakers when customizing inquiry-based strategies to specific science domains, in order to guarantee a more focused and effective implementation (Aulls & Shore, 2023; Chu et al., 2021).

Building upon existing research Kang (2022) and Sastradika and Defrianti (2019)) investigate the impact of inquiry-based learning on the development of scientific literacy among learners. Their research emphasizes the correlation between inquiry-based methodologies and the advancement of crucial abilities necessary for well-informed participation in society. This research highlights the diverse advantages that go beyond conventional academic results by presenting inquiry as a method to encourage both scientific conceptualization and wider community involvement. These insights enhance our understanding of the extensive effects that come from using inquiry-based practices in science teaching.

Although these studies collectively reinforce the claim for the beneficial impact of inquiry-based learning on learner results, it is clear that there is a lack of information regarding the viewpoints of teachers, specifically in the Namibian context. The present study seeks to address this discrepancy by specifically examining Namibian science teachers, offering valuable insights into their perspectives and encounters with inquiry-based teaching methods.

Cultural Context in Science Education

Studies indicate that the efficacy of teaching techniques can be impacted by the cultural environment (Liu et al., 2021). Nevertheless, the current body of literature frequently neglects the distinctive cultural subtleties that are unique to Namibia. This study aims to provide a comprehensive understanding of how cultural factors influence the implementation and reception of inquiry-based instructions in the Namibian educational system by focusing specifically on Namibian science teachers.

The impact of cultural context on science education has garnered increasing attention, and research has begun to illuminate the significance of including cultural subtleties in teaching approaches (Brown et al., 2020; Kulophas & Hallinger, 2021; Mathieson, 2023; Reid & Gardner, 2020). Scholars such as Kieran and Anderson (2019) and Matthews and López (2019) contend that by integrating culturally pertinent material and pedagogical approaches, teachers can augment learners' involvement and academic achievements. This study offers useful insights into the broader concept of cultural relevance in science education. However, there is a lack of literature that specifically focuses on the unique cultural setting of Namibia.

Expanding upon this, some researchers explored the convergence of culture and inquiry-based learning in the field of science education (Correia & Harrison, 2020; Koyle, 2021). Their research investigates how culturally situated inquiry might offer learners a more significant and relatable learning experience. These studies highlighted the significance of integrating inquiry-based practices with local cultural components in order to enhance their effectiveness, through an analysis of the cultural environments. Although these studies make a substantial contribution to the discussion on cultural factors in science education, there is still a lack of information in the existing literature regarding the specific application of these principles to Namibia's unique cultural environment.

Furthermore, some scholars have examined the influence of cultural responsiveness in professional development programs designed for science teachers (Abacioglu et al., 2020; Kieran & Anderson, 2019; O'Leary et al., 2020). These research studies highlighted the need of integrating cultural components into teacher training, since this can have a favorable impact on instructional practices and, as a result, improve learner outcomes (Abacioglu et al., 2020; Kieran & Anderson, 2019; O'Leary et al., 2020; Yu et al., 2021). Nevertheless, these studies primarily concentrate on other counties such as United states, which creates an emphasis on the necessity for research that tackles the particular cultural factors in various global locations, including Namibia.

In order to enhance the knowledge of the correlation between cultural context and science education, it is imperative to examine studies that specifically explored the cultural dynamics inside the educational system of Namibia. The present study focuses on science teachers in Namibia with the goal of filling this knowledge gap and offering a specific viewpoint on how cultural factors can influence the adoption and perception of inquiry-based teaching methods in Namibia. This study will provide a valuable contribution to the existing body of knowledge on culturally responsive scientific education. It will provide valuable insights that can be used to develop curriculum and instructional practices specifically designed for Namibia's distinct cultural environments.

Teacher Perceptions & Professional Development

Multiple research studies have examined the significance of teacher perspectives and professional growth in effectively carrying out inquiry-based learning (Hofer & Lembens, 2019; Margot & Kettler, 2019; Martins-Loução et al., 2020; Parsons et al., 2019; Seneviratne et al., 2019; Vieira et al., 2021). Although these studies offer significant insights, it is necessary to conduct a targeted analysis of the particular obstacles and achievements experienced by science teachers in Namibia when implementing inquiry-based instruction. The objective of this study is to address this discrepancy by conducting a detailed examination of teachers' encounters within the specific setting of Namibia.

The study conducted by Hofer and Lembens (2019) probes into the significance of teacher perspectives and professional development in the execution of inquiry-based learning. Their research provides valuable insights into the intricacies of teacher professional development. Their research explores the difficulties that teachers have while adopting inquiry-based teaching methods and highlights the crucial importance of ongoing and collaborative professional training. The results emphasize the necessity of continuous support systems and collaboration prospects for teachers to proficiently incorporate inquiry-based approaches into their instructional methodologies. Although this research makes a substantial contribution to the overall comprehension of professional growth, there is still a lack of study about the Namibian setting in this area.

In addition, a study conducted by Santos and Miguel (2019) examines the correlation between teacher beliefs, professional development, and instructional practices. The study emphasizes that teachers' beliefs regarding effective science instruction have a substantial influence on their readiness to embrace novel teaching approaches, which also aligns well with the study by Hofer and Lembens (2019). The study highlights the necessity of specialized professional development programs that not only impart technical skills but also tackle teachers' beliefs and attitudes towards inquiry-based learning. Although this research offers a theoretical framework, there is a lack of comprehension of the specific manifestation of these dynamics within the educational context of Namibia.

The present study seeks to enhance the existing body of literature by examining the specific experiences of science teachers in Namibia. It aims to provide a detailed and sophisticated analysis of the obstacles and achievements associated with teacher attitudes and professional growth in the implementation of inquiry-based approaches. Comprehending these variables in the Namibian context is essential for creating efficient professional development programs that address the particular requirements and conditions of science teachers in Namibia.

METHODOLOGY

The current study followed a quantitative research approach using an explanatory research design (Swedberg, 2020) to examine the attitudes and experiences of science teachers in Namibia regarding inquiry-based instruction. The objective of this design was to enhance understanding of the connections between variables, elucidating the aspects that impact teachers' viewpoints on the utilization of inquiry-based approaches in science education (Wheeler et al., 2019). The researcher sought to determine to identifying patterns, correlations and/or causal relationships in terms of teachers' and learners' behaviors, attitudes and beliefs towards inquiry; learners' level of interest and engagement in science; learners' baseline of knowledge science; levels and types of inquiry-based teaching pedagogies used by teachers; resource availability at schools to facilitate inquiry; classroom size to enable the implementation of inquiry and teachers' experiences in enacting inquiry approaches for teaching science.

Population & Sample

The study comprised a cohort of 133 science (chemistry and physics, grade 10 to geade 12 and physical science, grade 8 and grade 9) teachers from all fourteen educational regions within Namibia. The participants were chosen through a stratified random sampling method, which guaranteed that individuals from various geographical regions, school kinds, and degrees of teaching experience were included (Berndt, 2020; Conquest et al., 2023). Creswell and Creswell (2017) explain stratified random sampling as a technique used to ensure that subgroups within a population are represented proportionally in the sample. This method involves dividing the population into strata based on certain characteristics and then randomly selecting samples from each stratum. In this study, the teachers were selected based on their qualifications, teaching experiences and their school location in order to achieve more accurate and reliable results, as this accounted for variability within the population.

The target population for study included all science teachers in Namibia who have experience with inquiry-based instruction. In contrast, the accessible population consisted of science teachers who met the specific criteria such as: having at least three years of teaching experience, actively using inquiry-based instruction, working in resource-constrained schools, an equal balance of their geographical locations (i.e., rural and urban schools), and those who were willing to participate. This accessible population represents a subset of the target population that was practical and feasible for the researchers to reach and study.

Therefore, science teachers currently engaged in teaching at secondary schools in Namibia formed part of the population in this study. These teachers have diverse degrees of expertise to encompass a wide range of viewpoints. Moreover, the population of the participants included both teachers from rural and urban topographical settings, to get an impression of their experiences with inquiry-based instruction as a teaching approach.

Sampling Procedure

Schools were categorized based on their geographical locations (urban and rural). Teaching experience of the science teachers (novice, intermediate, and experienced) were also criteria used to categorize the teachers. Within each stratum, a random sample of schools was selected and science teachers from the selected schools were invited to participate in the study. The number of teachers from each region were roughly around nine. **Table 1** shows the number of participants per region and their schools' geographical locations. The school names provided are not the actual names of the schools; instead, pseudonyms were used for confidentiality purposes.

Data Collection

A structured questionnaire served as the primary instrument for data collection. The survey included items addressing teachers' demographics, their qualification levels, number of years of teaching experience in science subject, their school locations and the positions they held at school, i.e., subject teacher, head of department or school principal. And most importantly, the questionnaire addressed their perceptions of inquiry-based instruction. Likert scales and closed-ended questions were employed to quantify responses, facilitating subsequent statistical analysis (see **Appendix A**–Questionnaire survey).

The questionnaire comprised of two sections: section A and section B. Section A aimed at determining Namibian science teachers' contextual details in terms of their personal details such as their gender, age group, years of teaching experience in the science subjects, qualification in teaching the science subjects, school location (rural or urban), their educational region, their engagement in professional development in science subjects and resource availability for facilitating science practical work at their schools.

Section B, espoused to determine science teachers' conceptions of teaching science practical work through inquiry-based instruction in their classrooms. The main aspects highlighted in this section included:

Table 1. Participants per region & their schools' location (n=133)

Region	School name	Location	Number of science teachers
Region 1	Sunrise High	Urban	4
	Sunset Secondary	Rural	5
Region 2	Horizon High	Urban	6
	Mountainview Secondary	Rural	5
Region 3	Oasis High	Urban	5
	Desert Edge Secondary	Rural	4
Region 4	Riverbank High	Urban	6
	Valleyview Secondary	Rural	3
Region 5	Lakeside High	Urban	3
	Forestview Secondary	Rural	7
Region 6	Summit High	Urban	5
	Hilltop Secondary	Rural	4
Region 7	Beacon High	Urban	4
	Lighthouse Secondary	Rural	5
Region 8	Seaside High	Urban	3
	Cliffside Secondary	Rural	6
Region 9	Meadow High	Urban	5
	Prairie Secondary	Rural	4
Region 10	Skyline High	Urban	5
	Canyonview Secondary	Rural	4
Region 11	Oasis High	Urban	5
	Desert Edge Secondary	Rural	4
Region 12	Riverbank High	Urban	5
	Valleyview Secondary	Rural	4
Region 13	Lakeside High	Urban	5
	Forestview Secondary	Rural	6
Region 14	Summit High	Urban	5
	Hilltop Secondary	Rural	6

(a) teachers' views of inquiry-based instruction,

(b) teachers' practices, views, attitudes, and beliefs of using inquiry-based instruction in teaching of science practical work, and

(c) factors informing teachers usage and enactment of inquiry-based instructions during science practical work.

This section used a five-points Likert scale (ranging from one to five, where one, indicated 'strongly disagree', three, indicated 'neutral/undecided' and five, indicated 'strongly agree'. The questionnaire was developed by the researcher based on the research objectives and was validated by experts in the field such as experienced researchers with expertise in this specific subject area (mainly my senior colleagues who have developed and used questionnaires in similar contexts before) for clarity, relevance, and comprehensiveness. After the validation process, the questionnaire was piloted with a sampled teachers from five regions to test and assess the questionnaire's clarity, consistency, and appropriateness.

Following the pilot test, statistical analyses such as factor analysis and reliability testing were performed to ensure the questionnaire measures what it intended to measure. Additionally, correlations with existing validated measures or criterion-related validity were examined to assess the questionnaire's accuracy in predicting relevant outcomes. Adjustments were made based on feedback and results from these validation processes until the questionnaire finally demonstrated satisfactory validity and reliability for the intended research context. As presented earlier, the questionnaire instrument used in this study to assess teachers' views, practices, attitudes, and beliefs regarding inquiry-based instruction in science classrooms was subjected to reliability testing to ensure internal consistency. Cronbach's alpha reliability coefficient was calculated for the questionnaire items, and it was found to be at 0.85. This higher score, which is above a coefficient above 0.70 is generally considered acceptable and it showed a high level of internal consistency, suggesting that the items within each section reliably measured the same underlying constructs. It should also be noted that that items on the questionnaire were a mixture of both positive and negatively worded (see **Appendix A**).

Data Analysis

Quantitative data collected through the survey questionnaire was analyzed by means of the statistical packages for social sciences, IBM SPSS-PASW version 27. Initially, data was completed in an excel spreadsheet and data cleaning was done in accordance with the number of questions that were fully/correctly filed by the respondents. This was done to establish the actual number of respondents in the study. Descriptive statistics was done in form of standard deviation (SD), mean (M), frequencies, and percentages. Average values for the Namibian science teachers' conceptions were calculated using the IBM SPPSS-PASW, version 27) (IBM Corp., 2020). After the data analysis, data was presented in forms of tables and figures about teachers' conceptions of teaching science practical work through inquiry-based instruction and teachers' demographic information. The quantitative approach provided a systematic and numerical understanding of Namibian science teachers' viewpoints on the enactment of inquiry-based science education, offering generalizable insights into the larger population of science teachers in the country.

Table 2. Science teachers' views of inquiry-based instruction (n=133)

To determine science teachers' views of inquiry-based instruction	M	SD
Inquiry-based instruction is a learner-centered approach that invites learners to explore content by posing, investigating, & answering questions.	4.44	0.62
Through inquiry, learners are usually actively engaged in discovering information to support their investigations.	4.47	0.54
Inquiry-based instruction is a powerful way of learning science, regardless of a learner's language background	4.43	0.65
Inquiry-based instruction puts learners' questions at the center of the science curriculum.	4.34	0.64
Inquiry-based instruction places as much emphasis on research skills as it does on knowledge & understanding of science content.	4.32	0.67
In an inquiry-based classroom, learners are given opportunities to take ownership of their own learning.	4.47	0.58
Inquiry-based teaching inspires learners to learn more and to learn more thoroughly.	4.32	0.70
Average	4.36	0.64

Table 3. Science teachers' practices, views, attitudes, & beliefs of using inquiry-based instruction in teaching of science practical work (n=133)

To determine science teachers' practices, views, attitudes, & beliefs of using inquiry-based instruction in teaching of science practical work	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, & in light of alternative explanations, & communicate & justify their decisions.	4.37	0.58
Using inquiry-based instruction enables learners to develop the dispositions needed to promote and justify their decisions.	4.33	0.57
Inquiry-based learning improves learners' understanding of scientific concepts and increases their interest in the subject.	4.40	0.62
When learners are provided with autonomy of scientific inquiry, it enables them to conduct their own practical work.	4.32	0.63
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.	4.41	0.68
Average	4.36	0.65

DISCUSSION OF FINDINGS

Science Teachers' Views of Inquiry-Based Instruction

Several factors were used to determine teachers' views of inquiry-based instruction as depicted in **Table 2**. The conceptions of the respondents helped to determine the level of understanding of inquiry-based instruction in this study. To ascertain the respondents' level of understanding about inquiry-based instructions, the statements as represented in **Table 2**, were set in the questionnaire, which the respondents (n=133).

In **Table 2**, the inquiry-based instruction's effectiveness as a learner-centered approach was assessed by posing a question, exploring content through inquiry, and providing answers. The results, with a strong mean (n=133; M=4.44, and SD=0.62) and consistent SD, indicate a normal distribution of data, providing substantial support for the stated claim.

The participants significantly supported the notion that learners actively participate in acquiring information to assist their studies through inquiry, as evidenced by a high average score of 4.47 (SD=0.54). Furthermore, teachers recognized the effectiveness of inquiry-based teaching in science education, regardless of the language backgrounds of the learners, with an average score of 4.43 (SD=0.65). The discovery implies that teachers generally agree that inquiry-based methods are effective instruments for teaching science, regardless of the linguistic variation among learners.

Teachers' perceptions of inquiry-based instruction consistently emphasized the importance of prioritizing learners' questions as the focal point of the science curriculum (M=4.34 and SD=0.64). Similarly, the participants confirmed that inquiry-based training focuses on developing research abilities and comprehension of scientific concepts, as evidenced by an average score of 4.32 (SD=0.67). The results highlight the teachers' shared comprehension of the complex characteristics of inquiry-based instruction, acknowledging its significance in cultivating learners' ability to ask questions and promoting a comprehensive approach to scientific comprehension.

Moreover, the study investigated the perceived influence of inquiry-based practices on learners' autonomy, critical thinking, and sense of belonging. The participants strongly recognized the notion that an inquiry-based classroom empowers learners to assume responsibility for their own learning (M=4.47 and SD=0.58). Furthermore, the research uncovered a significant agreement (M=4.32 and SD=0.70) among teachers that inquiry-based instruction motivates learners to investigate scientific phenomena in a more comprehensive manner, which is in line with the educational objectives of nurturing curiosity and enhancing comprehension. The findings indicate that science teachers in Namibia hold a strong appreciation for inquiry-based instruction, acknowledging its capacity to improve different aspects of learners' educational experiences in science classrooms.

Science Teachers' Conceptions of Inquiry-Based Instruction

In the implementation of science practical work, teachers seem to possess well-informed perspectives, attitudes, and beliefs (conceptions) regarding their approaches to inquiry-based instruction. The findings from the questionnaire are presented in **Table 3**.

Table 3 presents a thorough summary of the data analysis on teachers' practices, opinions, attitudes, and beliefs related to the use of inquiry-based instruction in science practical work. The results show that the respondents generally agree, as evident by an average score of 4.37 and a SD of 0.58. This suggests that inquiry-based science teachings effectively stimulate learners' thinking. Teachers consider inquiry-based methods to be helpful for involving learners in scientifically focused inquiries, giving

Table 4. Factors informing teachers' usage & enactment of inquiry-based instruction during science practical work (n=133)

To determine factors informing teachers usage & enactment of inquiry-based instruction during science practical work	M	SD
The way I was taught in school as a learner and the way I was trained as a teacher during my teacher training.	3.74	1.11
My own understanding of what inquiry-based instruction is and its relevance and relatedness to practical work.	4.16	0.79
My own attitudes, views, and beliefs about the nature of science.	4.22	0.83
Amount of timetabled time for teaching science from curriculum & time to be spent by learners on doing science practical work.	3.74	1.12
Learners' behaviors, attitudes, and views on inquiry and science practical work	3.71	1.12
Learners' pace of learning and their interests in learning science.	3.64	1.15
Average	3.79	1.09

priority to evidence, and fostering critical thinking abilities. The consistent SD enhances the dependability of this shared perspective.

The study investigates the influence of inquiry-based training on learners' attitudes, as indicated by an average score of 4.33 and a consistent SD of 0.57. Despite the this mean, the constant SD indicates that teachers usually approve the notion that inquiry-based instruction facilitates the cultivation of the dispositions required for learners to advocate for and substantiate their decisions. Furthermore, the research examines whether the implementation of inquiry-based learning improves learners' comprehension of scientific concepts and augments their enthusiasm for the subject. The findings, characterized by an average value of 4.40 and a consistent SD of 0.62, confirm that participants usually support the assertion. This underscores the notion that skillful facilitation of inquiry-based learning has the potential to greatly enhance learners' comprehension and enthusiasm for science.

The results also reveal the level of individuality given to learners in scientific investigation, with a significant average of 4.32 and a consistent SD of 0.63. Teachers perceive inquiry-based instruction as a means to empower learners to independently perform practical work and develop confidence in scientific exploration. Furthermore, the study highlights the beneficial influence of inquiry-based learning on learners' involvement, autonomy in their learning process, and the creation of tangible products. Teachers assert that inquiry-based education, with an average of 4.41 and a SD of 0.68, enables learners to engage in higher-level learning. This approach fosters a desire for investigation and autonomy in project development.

Overall, the findings continuously demonstrate that teachers have a favorable view of inquiry-based instruction. Average score of 4.36 indicates a high favorable assessment, and SD of 0.65 is consistently stable. This study supports the general positive attitudes and opinions of teachers towards the incorporation of inquiry-based approaches in science practical work. It indicates that teachers collectively acknowledge the effectiveness of these methods in improving several areas of learners' scientific education.

Factors Informing Teachers' Enactment of Inquiry-Based Instruction

Examining teachers' classroom practices concerning their teaching pedagogies and orientations in executing science practical work is heavily dependent on the factors influencing or hindering the effective implementation of practical work in their classrooms. In the questionnaire survey, teachers were prompted to recognize, based on their experiences, the factors shaping their approach to implementing science practical teaching through inquiry-based instructions#. The findings from this segment of the survey are outlined in **Table 4**.

The study sought to investigate the factors that affect the implementation of inquiry-based instruction in science practical work by science teachers in Namibia. This was done by collecting data from 133 participants through the use of questionnaires. The initial element examined was the impact of teachers' prior experiences as learners and their training as teachers on their implementation of science practical work, yielding an average score of 3.74 (SD=1.11). This underscores a strong association between the educational backgrounds of teachers and their teaching methodologies, emphasizing the influence of past experiences on their current instructional approaches. Furthermore, the average score for teachers' comprehension of inquiry-based education was 4.16 (SD=0.79), suggesting that a strong understanding of this teaching method is associated with successful implementation in real-world tasks.

Additionally, the study examined the attitudes, perspectives, and convictions of teachers towards the essence of science NOS, resulting in an average score of 4.22 (SD=0.83). This highlights the important connection between teachers' understanding of the NOS and how they carry out science experiments, emphasizing how their philosophical beliefs impact their teaching decisions. The study also examined the influence of scheduled time for science practical work, as outlined in the Namibian curriculum papers. This resulted in an average score of 3.74 (SD=1.12). These findings indicate that the amount of time dedicated to teaching science has a significant impact on how teachers include learners in hands-on activities. This implies a clear connection between curriculum guidelines and the choices made by teachers.

The results also indicated that teachers' preferences for the incorporation of hands-on activities depend on the behaviors, attitudes, and perspectives of the learners towards inquiry and science practical work, with an average score of 3.71 (SD=1.12). Teachers consider learners' inclination to join and actively engage in inquiry-based activities when determining their inclusion in practical work. The study also examined how the speed at which learners acquire knowledge and their personal preferences influence the actions taken by teachers during science practical work. This analysis yielded an average score of 3.64 (SD=1.15). Teachers are more inclined to use inquiry-based teaching methods when learners' learning speed matches the targeted practical tasks and when learners show enthusiasm for these activities.

Additional variables, including the teachers' weekly workload, resource availability, class size, administrative responsibilities, peer technical support, support from regional offices, personal interests, and motivation for skill improvement, were also analyzed. The average score of 3.79 (with an SD of 1.09) suggests that Namibian science teachers have a strong grasp of the requirements set forth in the national science curriculum documents. This understanding influences their choices and behavior when incorporating inquiry-based teaching methods into science practical activities. Teachers' perspectives coincide with the focus on experiential activities specified in the curriculum requirements, indicating a thorough comprehension of the diverse aspects that impact their teaching methods.

CONCLUSIONS

Ultimately, this study examined the elements that influence the utilization of inquiry-based education by science teachers in Namibia during science practical experimentations. The findings illuminate the diverse factors that impact teachers' choices and methodologies in the classroom. An important factor to consider is the influence of teachers' prior learning experiences and their training, which demonstrates a clear connection between their educational backgrounds and teaching methods. An essential factor that emerged as crucial is a comprehensive conceptualization of inquiry-based instruction. Teachers who possess a firm grasp of this technique are more inclined to effectively engage learners in science practical work. This highlights the significance of ongoing professional development and training to improve teachers' educational abilities and methods.

Furthermore, the attitudes, perspectives, and convictions of teachers towards the essence of NOS have been identified as a significant determinant in shaping their instructional decisions. The presence of a robust correlation between philosophical attitudes towards science and practical work methods was apparent, underscoring the importance of fostering a holistic understanding of NOS and inquiry-based instruction among teachers. The study also emphasized the influence of extrinsic variables, such as curricular requirements, designated time for hands-on activities, and learners' behaviors and interests. The decisions made by teachers were significantly influenced by these external factors, highlighting the interdependence between instructional practices and larger educational frameworks.

Obstacles to successful inquiry-based instruction were highlighted as being constraints on resources scarcity, large class sizes, administrative responsibilities, and insufficient assistance from regional offices. These issues highlight the necessity for systematic enhancements in the distribution of resources, administrative assistance, and joint endeavors to improve the overall teaching and learning atmosphere. Moreover, the research shed light on how teachers' personal interests and enthusiasm for skill enhancement positively impacted their involvement in inquiry-based teaching. Promoting a culture of ongoing learning and offering opportunities for teachers to pursue their individual interests can enhance the dynamism and efficacy of the science education system particularly in the Namibian contexts.

Recommendations

Investing in continuing professional development for science teachers is essential to optimize the efficacy of inquiry-based instruction. Engaging in workshops, seminars, and training sessions that specifically target inquiry-based teaching approaches can equip teachers with the necessary skills and knowledge to effortlessly incorporate these practices into their classrooms. Collaborative platforms that facilitate the exchange of experiences and best practices among teachers can enhance their comprehension and application of inquiry-based instruction.

Efficient distribution of resources is crucial for achieving success in inquiry-based learning. It is crucial to tackle the recognized obstacles associated with inadequate apparatus and equipment to facilitating inquiry-based instructions. Education authorities should give highest importance to supplying essential supplies, guaranteeing that science teachers have the means to carry out practical experiments that involve inquiry-based instruction. This not only enables efficient teaching but also cultivates a favorable and captivating learning atmosphere for learners.

An essential element entails orchestrating the national science curriculum with the concepts of inquiry-based learning. An extensive evaluation should be conducted to more clearly incorporate inquiry-based approaches, highlighting the significance of hands-on activities in science education. Explicit directives about the distribution of time for inquiry-based instructions and a significant focus on learning objectives centered around inquiry will equip teachers with a clear plan for successful execution.

Recognizing the difficulties that teachers have and helping mechanisms are crucial elements of effective implementation. Implementing efficient processes for administrative work and providing rewards for ongoing learning and creativity can serve as strong motivators for teachers. To this end, cultivating a nurturing community that fosters peer cooperation and resource sharing can enhance a good and vibrant teaching environment. In essence, these guidelines seek to establish an environment that is favorable for both teachers and learners to excel in the field of inquiry-based science education.

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APPENDIX A: QUESTIONNAIRE FOR SCIENCE TEACHERS' CONCEPTIONS ON ENACTING SCIENCE PRACTICAL WORK THROUGH INQUIRY-BASED INSTRUCTIONS IN NAMIBIAN SCHOOLS

Section A: Personal & School Details

Mark your response by crossing (X) the number you think is most appropriate. Otherwise, indicate your response in the space provided.

Example: Do you have a laptop? If you do, then cross 1, as shown.

Table A1. Do you have a laptop? If you do, then cross 1, as shown

Yes, I have a laptop.	1 (X)
No, I do not have a laptop.	2

1. What is your gender?

Table A2. What is your gender?

Female	1
Male	2
Prefer not to say	3

2. In which age group are you?

Table A3. In which age group are you?

20 years and below	1
21-30 years	2
31-40 years	3
41-50 years	4
51 years and above	5

3. How many years of teaching experience do you have in teaching either physical science grade 8-grade 9 (revised curriculum), chemistry or physics grade 10-grade 11 (revised curriculum), physical science grade 8-grade 10 (old curriculum) or physical science grade 11-grade 12 (legacy)?

Table A4. How many years of teaching experience do you have in teaching either physical science grade 8-grade 9 (revised curriculum), chemistry or physics grade 10-grade 11 (revised curriculum), physical science grade 8-grade 10 (old curriculum) or physical science grade 11-grade 12 (legacy)?

Physical science grade 8-grade 9 (revised curriculum)	0-5 years	1
	6-10 years	2
	11-15 years	3
	16-20 years	4
	21 years & above	5
Chemistry or physics grade 10-grade 11 (revised curriculum)	0-5 years	1
	6-10 years	2
	11-15 years	3
	16-20 years	4
	21 years & above	5
Physical science grade 8-grade 10 (old curriculum)	0-5 years	1
	6-10 years	2
	11-15 years	3
	16-20 years	4
	21 years & above	5
Physical science grade 11-grade 12 (legacy)	0-5 years	1
	6-10 years	2
	11-15 years	3
	16-20 years	4
	21 years & above	5

4. Where is your school located?

Table A5. Where is your school located?

City	1
Rural	2
Semi-rural	3
Town	4

5. In which educational region is your school located?

Table A6. In which educational region is your school located?

Karas Region	1
Erongo Region	2
Hardap Region	3
Kavango East Region	4
Kavango West Region	5
Khomas Region	6
Kunene Region	7
Ohangwena Region	8
Omaheke Region	9
Omusati Region	10
Oshana Region	11
Oshikoto Region	12
Otjozondjupa Region	13
Zambezi Region	14

6. What position do you hold at school?

Table A7. What position do you hold at school?

Subject/classroom teacher	1
Head of department	2
School principal	3

7. On what basis are you employed?

Table A8. On what basis are you employed?

Full-time employment	1
Casual/relief teacher	2
Temporary/contractual employment	3

8. Which of the following subjects are you currently teaching? (*You can cross more than one box if necessary*).

Table A9. Which of the following subjects are you currently teaching? (*You can cross more than one box if necessary*)

Physical science grade 8	1
Physical science grade 9	2
Chemistry grade 10	3
Chemistry grade 11	4
Physics grade 10	5
Physics grade 11	6
Chemistry grade 12, *advanced subsidiary* (AS)	7
Physics grade 12, *advanced subsidiary* (AS)	8

Note. If you are teaching another subject/s, please specify: ………

9. What is/are your qualification/s to teach science (physical science grade 8-grade 9, chemistry and/or physics grade 10-grade 11)? (*You can cross more than one box if necessary*).

Table A10. What is/are your qualification/s to teach science (physical science grade 8-grade 9, chemistry and/or physics grade 10-grade 11)? (*You can cross more than one box if necessary*)

NONE	1
Teaching diploma in science education	2
ACE in science education	3
Postgraduate diploma in science education	4
Science degree	5
Degree in science education	6
Honours degree in science education	7
Honours degree in science	8
Master's degree in science education	9
Master's degree in science	10
PhD degree in science education	11
PhD degree in science	12

Note. If another qualification/s, please specify: ………………………………………………………………………………………………………

10. Are you currently doing any sort of professional development/studies in science education?

Table A11. Are you currently doing any sort of professional development/studies in science education?

Yes, I am doing professional development.	1
No, I am not doing professional development.	2

Note. If yes, please specify your study: ……

11. Have you received any form professional development related to the teaching science practical work in the last two years?

Table A12. Have you received any form professional development related to the teaching science practical work in the last two years?

Yes, I did.	1
No, I did not.	2

12. How would you describe your school in terms of the availability of resources for teaching science such as laboratories, consumables, apparatus etc.?

Table A13. How would you describe your school in terms of the availability of resources for teaching science such as laboratories, consumables, apparatus etc.?

Well resourced	1
Adequately resources	2
Poorly resourced	3
No resources	4

Section B: Teachers' Conceptions of Teaching Science Practical Work Through Inquiry-Based Instructions in Their Classrooms

13. **Teachers' views of inquiry-based instructions:** Using the scale given, please indicate your views about inquiry-based instructions in your science classrooms. Read each statement carefully and indicate to what extent you agree or disagree with each statement.

5: Strongly agree; 4: Agree; 3: Neutral/undecided; 2: Disagree; 1: Strongly disagree

Table B1. Teachers' views of inquiry-based instructions

13.1	Inquiry-based instruction is a learner-centered approach that invites learners to explore content by posing, investigating, and answering questions.	5	4	3	2	1
13.2	Through inquiry, learners are usually actively engaged in discovering information to support their investigations.	5	4	3	2	1
13.3	Inquiry-based instruction is a powerful way of learning science, regardless of a learner's language background.	5	4	3	2	1
13.4	Inquiry-based instruction puts learners' questions at the centre of the science curriculum.	5	4	3	2	1
13.5	Inquiry-based instruction places as much emphasis on research skills as it does on knowledge & understanding of science content.	5	4	3	2	1
13.6	Within inquiry-based instruction, teachers usually commit to providing rich experiences that provoke learners' thinking and curiosity to conduct their own experiments.	5	4	3	2	1
13.7	Using an inquiry-based approach allows learners to draw connections between scientific content and their own lives.	5	4	3	2	1
13.8	In an inquiry-based classroom, learners are given opportunities to take ownership of their own learning.	5	4	3	2	1
13.9	Inquiry-based teaching inspires learners to learn more and to learn more thoroughly.	5	4	3	2	1
13.10	Inquiry-based teaching methods can benefit both culturally and linguistically diverse learners and learners with special needs and learning difficulties.	5	4	3	2	1
13.11	An inquiry-based approach to teaching can increase learners' achievement and narrow the gap between high- and low-achieving learners.	5	4	3	2	1
13.12	When used in place of a traditional textbook approach, an inquiry-based approach can yield significantly higher achievement for learners with learning difficulties.	5	4	3	2	1
13.13	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.	5	4	3	2	1
13.14	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.	5	4	3	2	1
13.15	Inquiry-based learning enables teachers to help learners get from the curiosity stage into critical thinking and deeper levels of understanding of science concepts.	5	4	3	2	1
13.16	In an inquiry-based classroom, teachers are usually viewed as not doing anything, as learners usually formulate questions and seek out answers.	5	4	3	2	1

14. **Teachers' practices, views, attitudes and beliefs of using inquiry-based instructions in the teaching of science practical work:** Use the provided scale to rate your teaching practices, views, attitudes, and beliefs about using inquiry-based instructions to facilitate science practical work in your classroom. Read each statement carefully and indicate to what extent you agree or disagree with each statement.

5: Strongly agree; 4: Agree; 3: Neutral/undecided; 2: Disagree; 1: Strongly disagree

Table B2. Teachers' practices, views, attitudes and beliefs of using inquiry-based instructions in the teaching of science practical work

14.1	Inquiry-based science instruction challenges learners' thinking by engaging them in scientifically oriented questions in which they learn to prioritize evidence, evaluate explanations, & considering alternative explanations, & communicate & justify their decisions.	5	4	3	2	1
14.2	Using inquiry-based instructions enables learners to develop the dispositions needed to promote and justify their decisions.	5	4	3	2	1
14.3	Inquiry-based learning improves learners' understanding of scientific concepts and increases their interest in the subject.	5	4	3	2	1
14.4	When learners are provided with autonomy of scientific inquiry, it enables them to conduct their own practical work.	5	4	3	2	1
14.5	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.	5	4	3	2	1
14.6	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.	5	4	3	2	1
14.7	Using inquiry-based instructions in science practical work helps learners improve their understanding, develop their problem-solving skills, and understand the nature of science.	5	4	3	2	1
14.8	Inquiry-based instructions encourage learners to make links between their theoretical and practical knowledge.	5	4	3	2	1
14.9	Inquiry-based instruction supports science practical work by keeping learners focused on the task while they are engaged in hands-on activities.	5	4	3	2	1
14.10	Inquiry-based instruction prepares learners' minds for science practical work by providing background information on what they are investigating.	5	4	3	2	1
14.11	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.	5	4	3	2	1
14.12	Inquiry-based learning as a steppingstone towards practical work provides opportunity for experimental learning, in which a learner can prove a scientific theory rather than memorizing facts.	5	4	3	2	1

15. **Factors informing teachers usage and enactment of inquiry-based instructions during science practical work:** Please rate how the following factors inform your use and enactment of inquiry-based instructions during science practical work in your classrooms. Use a scale as shown below. Read each statement carefully and indicate to what extent the following factors influence your choices for enacting science practical work.

5: Very influential; 4: Well influential; 3: Marginally influential; 2: Not well influential; 1: Not very influential

Table B3. Factors informing teachers usage and enactment of inquiry-based instructions during science practical work

15.1	The way I was taught in school as a learner and the way I was trained as a teacher during my teacher training.	5	4	3	2	1
15.2	My own understanding of what inquiry-based instruction is and its relevance and relatedness to practical work.	5	4	3	2	1
15.3	My own attitudes, views, and beliefs about the nature of science.	5	4	3	2	1
15.4	Amount of timetabled time for teaching science from curriculum & time to be spent by learners on doing science practical work.	5	4	3	2	1
15.5	Learners' behaviours, attitudes, and views on inquiry and science practical work.	5	4	3	2	1
15.6	Learners' pace of learning and their interests in learning science.	5	4	3	2	1
15.7	My teaching/workload, i.e., the number of periods/lessons I have on a weekly basis.	5	4	3	2	1
15.8	The availability of resources, apparatus, and equipment to carry out practical science work.	5	4	3	2	1
15.9	The number of learners in my science classrooms.	5	4	3	2	1
15.10	The amount of non-teaching-related administrative work, i.e., gathering continuous assessment (CA) marks for learners.	5	4	3	2	1
15.11	Type of technical support & assistance I get from fellow teachers at my school, i.e., peer planning & preparation of lessons.	5	4	3	2	1
15.12	Type of technical support & assistance I get from regional office, i.e., workshops on conducting science practical work.	5	4	3	2	1
15.13	My eagerness to acquire more skills & knowledge about essence of engaging learners in inquiry-based science practical work.	5	4	3	2	1
15.14	My personal interests in understanding the influence that inquiry-based instructions have on science practical work and alternatively learners' conceptualization of scientific knowledge.	5	4	3	2	1

Thank you very much for your participation!!