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Grade 8 Physical Science Teacher-Led Demonstrations in Oshikoto, Namibia: Pedagogy Analysis

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Abstract

Scientists from almost every country in the world agree that hands-on practical work is an important part of teaching and learning science. The National Curriculum for Basic Education advocates for a knowledge-based society in Namibia, which is to be realized by engaging learners in hands-on, practical activities. Teachers in Oshikoto Region of Namibia orchestrate practical demonstrations regardless of calls from the National Curriculum for Basic Education for the enactment of a learner-centred pedagogy. The pedagogical orientations of Grade 8 Physical Science teachers when orchestrating science practical demonstrations were investigated in this sequential explanatory mixed methods study. The study collected quantitative data through a questionnaire survey that was administered to 87 grade 8 physical science teachers. This was followed by qualitative data collected by means of class observations and semi-structured interviews with 10 teachers who initially participated in the study. Findings from this study revealed that majority of teachers in the Oshikoto Region exhibit a preference for teacher-orchestrated demonstrations over entrusting practical activities to learners. Contextual factors such as a lack of resources to conduct practical work, insufficient curriculum time for practical lessons, and large class sizes are considered to influence this preference. Teachers maintain that these demonstrations support learners in conceptualising scientific phenomena, acquiring practical skills, and developing interests in science. Through teacher-orchestrated demonstrations, pedagogical orientations such as inviting learners to make predictions, asking learners to explain their observations, and facilitating class discussions after demonstrations are executed by teachers. This suggests that although demonstrations are teacher-orchestrated, teachers and learners interact through these actions to ensure that learners are cognitively engaged.

Keywords: practical work, teacher-led, demonstrations, physical science, knowledge-based society

Science researchers accept the importance of hands-on engagement in the teaching and learning of science practically in every nation on the globe. Namibia, a nation on Africa's south-west coast, recognizes the value placed on practical work, as do other nations. In the Physical Science curriculum for the junior secondary phase (JSP), the Ministry of Education, Arts, and Culture (MoEAC) establishes the significance of studying science as increasing the learners' knowledge and understanding of the world they live in through critical thinking, investigating phenomena, interpreting data, and also applying knowledge to practical skills (MoEAC, 2015).

Additionally, it is stated that one of the key learning areas in the NCBE, the natural sciences, "contributes to the foundation of a knowledge-based society by empowering learners with the scientific knowledge, skills, and attitudes to formulate hypotheses and to investigate, observe, make deductions, and understand the physical world in a rational, scientific way" (MoEAC, 2018, p. 13). For each topic, the curriculum document provides further details and recommendations for potential hands-on activities and/or demonstrations that teachers should carry out (MoEAC, 2015). A study by Babalola, Lambourne, and Swithenby (2019) found that in sub-Saharan Africa, teachers maintain that practical work reinforces the theory learned, supports skill development, motivates learners, and promotes economic development as well as recognising the importance given to practical work.

Intention and format of practical activity can differ. According to Millar, Le Marechal, and Tiberghien (1999), it is important to be clear about the various types of practical work, their various purposes, and the pedagogical approaches for each type if researchers are to investigate the efficiency of practical work in accomplishing educational goals. The majority of practical work in sub-Saharan countries is teacher-organized practical demonstrations, despite calls for learners to engage in independent scientific inquiry where they have autonomy in formulating their own investigation and planning an inquiry. This is because of factors like a lack of resources, large classes, and a lack of class time (Shivolo, 2018).

This study explored the pedagogical orientations of Physical Science teachers when orchestrating science practical demonstrations at schools in Oshikoto Region, Namibia. The author worked for nearly 15 years as a Physical Science teacher in this region and has a particular interest in understanding how other teachers enact science demonstrations in their classrooms. Most schools in Oshikoto Region, are under-resourced in terms of science facilities, such as equipment, apparatus, consumables, and even laboratories. The Education Management Information Systems (EMIS) 2020 report shows that out of 109 schools where Physical Science is offered as a subject, only 48 are equipped with science laboratories. The benefit of teachers using demonstrations in such a context has been recognized. Jerrim, Oliver, and Sims (2022) outlined that inquiry-based science teaching and demonstrations can increase learners' cognitive involvement as these strategies involve learners conducting their own scientific experiments and investigations instead of mostly receiving science knowledge directly from teachers.

The value of demonstrations is also advocated by the Namibian Ministry of Education, Arts and Culture, where it is prescribed in the Physical Science curriculum for the junior secondary phase (grades 8 and 9) that learners should be exposed to practical activities, approaches, and demonstrations during instruction (MoEAC, 2015). The Physical Science curriculum for the junior secondary phase consequently outlined that, relative to the general and specific objectives to be achieved at the end of each topic or area of content, teachers should decide when "it is best to convey content directly; it is best to let learners discover or explore information for themselves or when they need directed learning" (MoEAC, 2015 syllabus, p. 4). This paper then presents the literature review, the methods of data collection, findings, discussion as well as the recommendations.

Literature Review

1. Teaching And Learning Science Through Practical Work

The literature abounds with numerous characterizations of the construct "practical work". To this end, science scholars seem to gear their understanding towards the inclusion of hands-on activities in their descriptions of what practical work encapsulates. This is reflected in the definition by Lunetta, Hofstein, and Clough (2007) who described practical work as "learning experiences in which students interact with materials or with secondary sources of data to observe and understand the natural world" (p. 2). According to Wei and Liu (2018), practical work refers to a variety of hands-on activities used in science classes at both primary and secondary levels. According to Hofstein, Kipnis, and Abrahams (2013), practical work is typically acknowledged as an essential component of school science teaching and learning.

According to Roth et al., (2006), practical work may be broadly classified into whole-class practical activities and independent practical activities. Whole-class practical activities involve mainly teacher-orchestrated demonstrations of phenomena and objects, whereas independent practical activities involve activities "carried out by the students themselves, usually working in small groups" (Millar et al., 1999, p. 33). Whole-class teacher-orchestrated demonstrations range from simple displays of objects such as the model of the heart to display objects related phenomena or showing how substances react with oxygen. This study focused on the enactment of teacher-orchestrated demonstrations, and the pedagogical orientations that teachers display during these demonstrations.

Hattingh, Aldous, and Rogan (2007) identified four levels into which science practical work may be classified. The four levels are positioned in terms of decreasing learners' autonomy in carrying out practical work. Level 1 involves mainly teacher-directed demonstrations, whereas level 4 involves learner-directed activities. Table 1 shows the four levels of practical work defined by Hattingh et al., (2007). It is evident that levels 1 and 2 refer to practical work in the form of demonstrations. For level 1 practical work, a teacher uses demonstrations to help learners develop an understanding of science concepts by using materials or specimens that are easy to obtain within a given environment. For level 2 practical work, a teacher still leads demonstrations, but learners are partly involved as they assist teachers in planning and carrying out demonstrations. Levels 3 and 4 reflect an inquiry-based approach where more autonomy is entrusted to learners in investigating phenomena through practical activity.

Table 1: Four Levels of Complexity in Science Practical Work: A Classification Framework

Level	Types of science practical work
1	Teacher uses classroom demonstrations to help develop concepts. Teacher uses specimens found in the local environment to illustrate lessons.
2	Teacher uses demonstrations to promote some form of learner inquiry. Some learners assist in planning and performing the demonstrations. Learners participate in closed (cook-book) practical work. Learners communicate data using graphs and tables.
3	Teacher designs practical work in such a way as to encourage learner discovery of information. Learners perform guided discovery type practical work in small groups engaging in hands-on activities. Learners can write a scientific report in which they can justify their conclusions based on the data collected.
4	Learners design and do their own 'open-ended' investigations. Learners reflect on the quality of the design and data collected and make improvements when and where necessary.

Learners can interpret data in support of competing theories or explanations.

Source: Hattingh, Aldous and Rogan (2007)

Despite reformed school science curricula that underlie inquiry-based science education, practical work in the form of teacher demonstrations remain ubiquitous in science classes in Namibia (MoEAC, 2018) and globally (Basheer, Hugerat, Kortam & Hofstein, 2017; Daluba, 2013). Odom and Bell (2015) described a demonstration or lecture demonstration (as they are synonymously referred to in literature) as referring to learners "watching the teacher do experiments, lecture demonstrations are teacher-led with students passively observing the results, the teacher may pose questions or ask for predictions, but students are not physically engaged with science materials or socially engaged with peers" (p. 88).

Odom and Bell (2015) further stated that "although laboratory science became more common in the twentieth century, demonstrations have continued to be a mainstay in science classrooms" (p. 87). The reason that demonstrations are not yet completely phased out of teaching science, is due to the constraints hindering the effective implementation of practical work in science such as lack of resources and larger classrooms (Odom & Bell, 2015).

According to Ramnarain (2010), teachers use demonstrations to familiarize learners with procedures of inquiry. During this types of demonstrations, a teacher places the learners' focus on the event or phenomenon being demonstrated. During a practical demonstration, the Predict–Observe–Explain (POE) method and discrepant events are the most useful aspects of a demonstration. Shivolo (2018) gives an example of a demonstration where the POE method is applied. He refers to the expansion of solids, using a ball and ring apparatus where "learners are expected to predict what would happen to the metallic ball before it is heated, with respect to moving through the metallic ring once it is heated, and then through observation, they are able to explain their initial prediction" (p. 29). Activities based on the POE method can therefore help learners develop skills such as hypothesising, experimentation and drawing conclusions (Ramnarain, 2010).

Demonstrations can also be used to illustrate discrepant events "where learners observe unexpected results that are contradictory to their normal experience or expectations" (Ramnarain, p. 41). For example, learners have the belief that when water is cooled below 4°C it would contract like other substances. However, through a demonstration they come to realise water behaves unusually between 0 °C and 4 °C.

2. Teacher Pedagogical Orientation in Orchestrating Practical Demonstrations

According to Magnusson, Krajcik and Borko (1999) an orientation is defined as "a general way of viewing or conceptualizing science teaching" (p. 97). Anderson and Smith (1987) also used the term 'orientations' to describe teachers' "general patterns of thought and behaviour related to science teaching and learning" (p. 99). Hewson and Hewson (1987) conceptualise a pedagogical orientation similarly as they refer to it as a "set of ideas, understandings, and interpretations of experience concerning the teacher and teaching, the nature of content of science and students and the learning which the teacher uses in making decisions about teaching, both in planning and execution" (p.194).

In this study, pedagogical orientations are therefore viewed as science teaching orientations and described as the knowledge and beliefs teachers have about teaching science at a particular grade level (Magnusson et al. 1999). Pedagogical orientations manifest in pedagogical actions which may include types of questions asked, the use of prompts, and facilitating collaboration and reflection (Gervasoni, Hunter, Bicknell, & Sexton, 2012). In accordance with this conceptualization of pedagogical orientation, this research investigated the pedagogical orientations of Namibian Physical Science teachers when enacting teacher-orchestrated chemistry demonstrations in grade 8.

The following aspects in Namibian teachers' pedagogical orientations with regards to practical demonstrations are investigated: teachers' pedagogical preferences; pedagogical actions; and views on the learning outcomes. Accordingly, the research was guided by the following question:

What pedagogical orientations do Grade 8 teachers display when orchestrating science practical demonstrations?

Method

This study used a "sequential explanatory mixed methods" methodology. According to Creswell and Creswell (2017), mixed methods is a strategy that combines both quantitative and qualitative data in a single study. They also demonstrated that combining both approaches together is crucial, as opposed to employing only one separately, to help the researcher fully comprehend the research problem at hand. Qualitative data are employed in a sequential explanatory mixed-method approach to provide feedback on and explain quantitative findings (McMillan & Schumacher, 2010).

The process of collecting data during this study comprised two phases. Phase one involved collecting quantitative data by means of a questionnaire survey of 87 grade 8 Physical Science teachers from Oshikoto Region in Namibia. The questionnaire is structured into sections that comprise items relating to learning outcomes of science practical demonstrations, the type of demonstrations enacted, the impact of contextual factors on the types of demonstrations, and teachers' pedagogical actions during demonstrations. The questionnaire was validated for the above constructs by a panel of three science education researchers. The adapted questionnaire was piloted with three Namibian grade 8 Physical Science teachers to establish the readability of items before it was adopted for this study. Since the questionnaire's successful piloting demonstrated the validity of its design, no adjustments were necessary. Phase two, which was the qualitative data gathering process comprised semi-structured interviews after classroom observations. Ten teachers participated in this methodology; they were selected specifically from the group of 87 teachers who had responded to a survey and had said they preferred teacher-orchestrated demonstrations.

Questionnaire data (quantitative) were analysed using IBM's Statistical Package for Social Sciences (SPSS) software which involved the calculations of percentages and generation of graphs. The analysis of classroom observation and interview data were facilitated by using ATLAS.ti 7 software and were subsequently coded deductively, and classified, to determine patterns in explanations for teachers' chosen options in the questionnaire survey. Such patterns and trends were later interpreted by means of Thematic Analysis (TA) and translated as assertions which were corroborated by excerpts from classroom and interview data. According to Clarke and Braun (2013), TA is described as a “method for identifying and analysing patterns in qualitative data” (p. 3).

Findings

The findings from the analysis of the questionnaire survey were integrated with the findings from the interviews, and classroom observations into a coherent whole. The interview and classroom observation explained some of the findings which emerged from the questionnaire analysis. This integration of quantitative and qualitative data supported the production of themes on the pedagogical orientations of grade 8 teachers when orchestrating chemistry demonstrations. These themes are presented next.

Theme 1: Pedagogical Preference for Teacher-Orchestrated Demonstrations

In the questionnaire, teachers were asked to indicate their preference for either doing a teacher-orchestrated demonstration or for entrusting learners to do practical work. Responses to the questionnaire showed that 56.3% of teachers expressed the preference to orchestrate demonstrations, whereas 43.7% indicated that they would entrust learners to carry out practical work. In the investigation of the role of contextual factors informing this choice, there was a section in the questionnaire where teachers were asked to rate the degree of the impact of certain contextual factors on a scale of 1 to 5, where 1 indicated “no impact” and 5 indicated a “high impact”. The analysis of data revealed that teachers considered the availability of equipment and resources, the amount of lesson timetabled time for practical activities, and the number of learners per class (class size) as key factors in their decision to do teacher-orchestrated demonstrations rather than having learners do practical activities. These finding are presented in Table 2.

Table 2: Rating of Contextual factors in decision to do teacher-orchestrated demonstrations

	Degree of Impact N(%)				
Contextual factors	**No impact 1**	**2**	**3**	**4**	**High impact 5**
Availability of equipment and resources N (%)	2(2.3%)	4(4.6%)	5(5.7%)	19(21.8%)	57(65.6%)
Lesson timetabled time N (%)	3(3.4%)	2(2.3%)	16(18.4%)	24(27.6%)	42(48.6%)
Class size N (%)	0(0%)	11(12.6%)	7(8.1%)	31(35.6%)	38(43.7%)

Note. N = number of teachers who made this choice.

From this table, it is evident that 76 teachers (87.4%) rated either 4 or 5 the impact of the availability of resources in their decision to do teacher-orchestrated demonstrations. A similar result was noted for the impact of class size where 79.3% of teachers rated the importance of this factor as either 4 or 5. For lesson timetabled time, 75.9% of surveyed teachers rated the impact level of this factors as either 4 or 5. In the interviews, the teachers elaborated upon the influence of these contextual factors on their preference for doing demonstrations compared to learner-centred practical work. The following excerpts from a teacher interviews highlight the problem of a lack of resources teachers experience and how this impacts on their decision to do demonstrations:

> *Due to the fact that the provision of resources when it comes to science, that's not so good and we don't have enough resources, at the same time we are trying to save so that we can do other practicals, I could not give learners to do individual or group works, rather I demonstrate and [it is] for them to observe.*
>
> *So, the reason is because our school doesn't have any apparatus to use during practical and when we have conducted this practical we have to borrow from the other schools, so actually we don't have materials for practical and we don't, most of the time we only do theory.*

The excerpt below elaborates upon how the lack of teaching time left the teacher with little option other than to do a whole class demonstration:

The purpose of, to demonstrate to the whole class was just to save time, because demonstrating group or going from group to group, is very time consuming and a lesson is just 40 minutes, so that was just to save time and to finish with the demonstration at once

Theme 2: Teachers perceive that teacher-orchestrated demonstrations leads to a variety of earning outcomes

In the questionnaire, teachers were asked to respond to a list of six envisaged learning outcomes for teacher-orchestrated demonstrations by rating them on a 5-point scale, where 1 indicated that the learning outcome is "unimportant", 2 indicated that the learning outcome is "of little importance", 3 indicated that the learning outcome is "moderately important", 4 indicated that the learning outcome is "important" and 5 indicated that the learning outcome is "highly important". Teachers considered the following learning outcomes as either "important" or "highly important" during teacher-orchestrated demonstrations: helping learners to understand science concepts (97.7% teachers); developing learners' science skills such as handling apparatus (93.1% teachers); stimulating learner interest in science (95.4% teachers); helping learners to observe physical changes in science phenomena (95.4% teachers); and developing social skills in learners (96.6% teachers). Figure 1 exemplifies these responses.

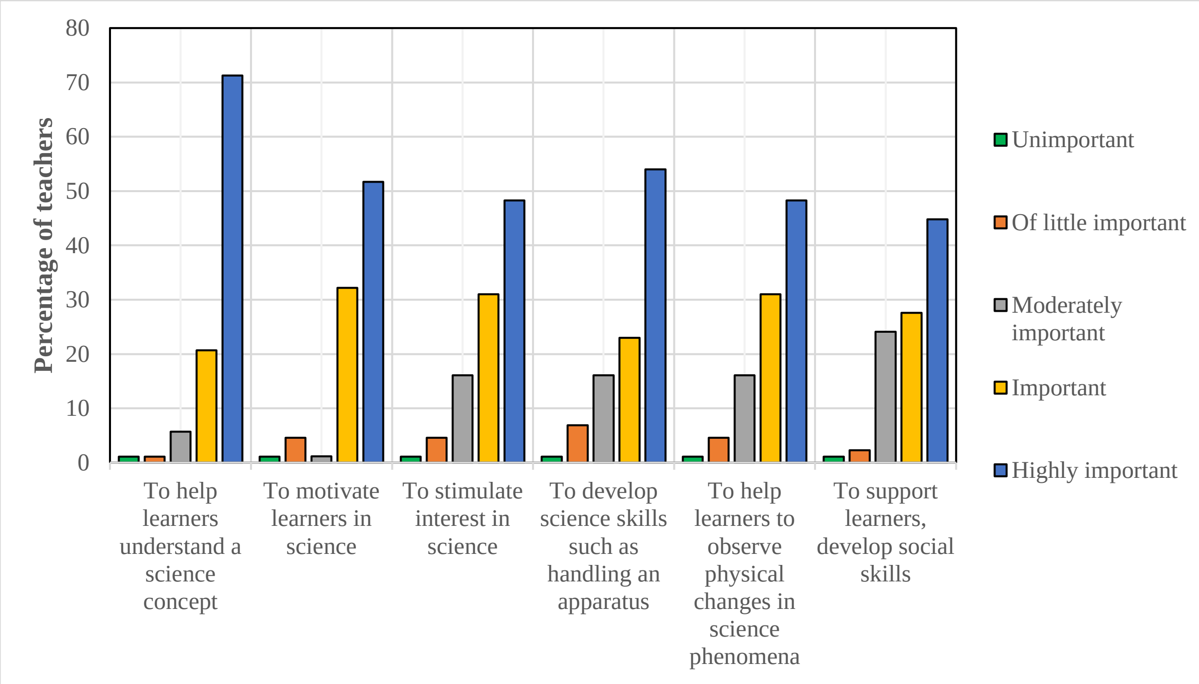

Figure 1: The Learning Outcomes for Orchestrating Chemistry Demonstrations

With regards to the learning outcome of supporting learners to understand a concept, the teachers expatiated on this benefit during the interviews. The following responses were elicited:

> *Learners were able to explain expansion in solids, that's why I demonstrate to them how expansion take place in solids, by using a ball and ring.*

> *The purpose as I first said I explained the theory the purpose of this practical, it was, just to affirm that the process of expansion, before and after heating the ball, just to show the learners practically.*

> *Yeah, the learning outcome is for the learners to understand that once matter is heated, they can expand, especially solids can expand just like gas and liquid particles.*

It would appear from the above responses that the demonstrations provide an opportunity for learners to visualise phenomena, and this visualisation leads to conceptual understanding. This benefit is also revealed in their assessment of "helping learners to observe physical changes in science phenomena" where a great majority of teachers recognised its importance. This is evident in the excerpt below:

> *The learners were observing as I, the teacher was busy with a demonstration, but they were also active at some points because they have to answer questions that I have asked them, and they also have to feel the test tube when we were doing the demonstration to see if the test tube has become hot or colder*

Although the demonstrations were teacher-orchestrated, teachers maintained that during the demonstrations they would often invite learners to assist them by setting up the apparatus or reading measurements from devices. This is revealed in the following passages from the interviews:

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The role of the learners was to observe when the teacher is doing the demonstration, it was also to participate, for example they were asking questions and also to help, to assist the teacher for example in holding some of the materials during the experiment.

The role of the learners in the lesson was to observe the experiment, they have to observe, and they have to answer questions, and also, they have to handle the apparatus since I called one learner to come and help in the demonstration.

The development of social skills was also considered a strong outcome of demonstrations. Teachers hold the view that during demonstrations sufficient opportunity needs to be provided for learners to interact with each other. This interaction appears to be at the stage where learners are asked to explain their observations. Here teachers see the exchange of ideas within a social setting as potentially contributing to the development of social skills.

Theme 3: The pedagogical actions of teachers are supportive of an interactive approach in teaching science

In a section of the questionnaire, teachers were asked to indicate an option on the frequency with which they displayed certain pedagogical actions when orchestrating demonstrations. Teachers were required to elect one of the following options for each listed pedagogical action: no demonstrations; a few demonstrations; about half the demonstrations; most demonstrations or all demonstrations. The data analysis revealed that for either "most demonstrations" or "all demonstrations" the majority of teachers displayed the following pedagogical actions: ask learners to predict the results (89.7% teachers); talk and show the experiment while learners listen (67.5% teachers); ask learners to explain their observations (95.4% teachers) and ask learners to compare their observations to their predictions (78.5% teachers). Figure 2 depicts the results obtained in this regard.

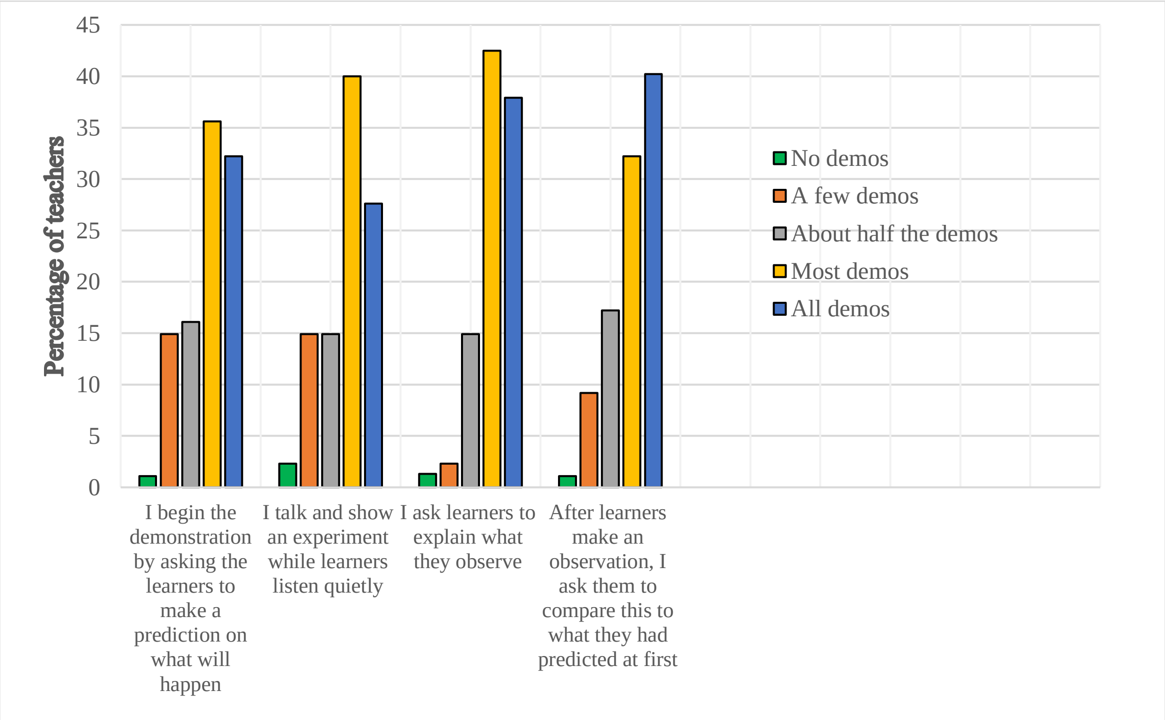

Figure 2: Teachers' Pedagogical Actions in Orchestrating Chemistry Practical Demonstrations.

During classroom observations of teacher-orchestrated practical demonstrations, it was evident that the teachers employed various pedagogical actions. These observations resonate with their responses to the quantitative questionnaire where teachers responded that they frequently employed several pedagogical actions when conducting practical demonstrations. It emerged from these observations that teachers employed both interactive and non-interactive approaches when leading teacher-orchestrated demonstrations. This enabled the researcher to classify their pedagogical actions as being interactive or non-interactive. The observed pedagogical actions are reflected in Table 3.

Table 3: Interactive and Non-Interactive Approaches to Teaching Science

Interactive approach to teaching science	**Non-interactive approach to teaching science**
There is teacher-learner and learner-learner interactions in new knowledge construction	There is no teacher-learner and learner-learner interactions
The teacher asks learners to make a prediction on what will happen during the demonstration	The teacher asks learners to recall what they learned in a previous lesson and uses the demonstration confirm theory
Learners assist the teacher during the demonstration by handling apparatus and they are asked to describe their observations	The teacher carries out the demonstration and describes what is happening while learners listen quietly
After the demonstration, the teacher facilitates a class discussion, where learners explain their observations and are scaffolded in constructing new knowledge	After the demonstration, the teacher provides an explanation for what happened and the learners take down notes.
The teacher asks learners to make observations and then to explain their observations and later draw a conclusion	Learners are asked to describe their observations, and the teacher explains learners' observations and then consolidates learners' answers

Although in large measure there was resonance between the pedagogical actions claimed by teachers in the questionnaire and the actioned observed in the lessons, there was also some discrepancy between these two datasets. For example, 89.7% of teachers indicated on in their questionnaire responses that they ask learners to predict the results in either "most demonstrations" or "all demonstrations". However, in only one of the observed lessons did the teacher enact this action.

Consequently, in large measure the teacher invoked the learners to "observe" the phenomena and "explain" their observations of the POE strategy that was developed by White and Gunstone (1992) but did not provide an opportunity for them to make a prediction on the result. This finding is illustrated in a lesson taught on the expansion of solids. After showing the metal ball passing through the ring, the teacher failed to ask the class to make a prediction on what would happen to the ball when it was heated.

This was an opportunity lost for the teacher to get learners to articulate their existing ideas. The teacher proceeded to heat the ball, and then showed the class that it no longer passed through the ring. The learners were asked to describe what they had observed, and thereafter to advance an explanation for this observation. The teacher prompted the learners in their explanation by referring them to the particle model of matter that had been previously taught.

Discussion and Conclusion

Although a larger study is necessary to provide a broader overview of the practical work in Namibian science classes, the findings of this study for the Oshikoto Region may have significance for the entire country. The findings revealed that, given the existence and influence of contextual factors such as lack of resources to conduct practical work, insufficient time allocated for practical lessons and the issue of large class sizes, it would appear that in the Oshikoto Region, teacher-orchestrated demonstrations are regarded as being the most effective forms of practical work by which learners can derive learning benefits, such as acquiring an understanding of science concepts, developing practical skills and developing an interest in science.

In terms of the levels of practical work presented by Hatting, Aldous and Rogan (2007), it is evidently clear that the practical work is predominantly levels 1 and 2, where level 1 is strongly teacher-centred demonstrated, and level 2 albeit still a demonstration reflects more effort at learner engagement. From the findings, it can also be seen that although the demonstrations are teacher orchestrated, the pedagogical actions of the teacher suggest that the learners are cognitively engaged. During the demonstration learners are requested to make observations and they are prompted to explain their observations. After the demonstration, learners are engaged in class discussions.

From this, an inference can be made that the chemistry demonstrations conducted by teachers in the Oshikoto Region of Namibia take on a form of a whole class demonstration. Although this state of affairs in the science classroom does not adhere to the prescripts of the school science curriculum, the findings do reflect that teachers acknowledge the important role that practical work plays in science learning. This is a significant baseline from which teachers can innovate their practice by exploring opportunities by which inquiry-based learning maybe gradually infused into their practice.

Rogan and Grayson (2003) maintains that, the implementation of an innovation should occur in manageable steps. He introduces the notion of a Zone of Feasible Innovation (ZFI), by analogy with Vygotsky's zone of proximal development to suggest that the implementation of a reformed curriculum needs to be gradually progressed in stages. This implies that if the existing practice of a teacher in practical work is dominated by teacher-centred demonstration, it is unreasonable to demand a quick transition to guided or open inquiry. A gradual transition for Namibian teachers would be that they introduce a new teaching strategy like the Predict-Observe-Explain (POE) that could be used in association with demonstrations. Further research might thus explore the feasibility of the implementing a POE strategy in Namibian science classrooms where contextual factors identified by this study have significance.

The findings of this research also have significance in extending our knowledge on the nuances of school science practical demonstrations. Despite a worldwide curriculum focus on scientific inquiry in the doing of practical work, demonstrations have continued to be the mainstay of practical work in science classrooms. The reason for this as is revealed by this study is due to the intrinsic and extrinsic school factors.

Demonstrations have traditionally been associated with ‘show and tell’ of scientific phenomena based on passive observation, however, this study has revealed that demonstrations can be both interactive and non-interactive based on the pedagogical actions taken by teachers. In assuming a constructive perspective to learning and teaching, learners can be probed on their existing knowledge and ideas of phenomena by being asked to make a prediction. Such a prediction can then be investigated by a teacher-guided demonstration where learners are scaffolded by prompting questions in making an observations and then offering an explanation for such an observation. The initial prediction is then evaluated against the explanation, leading to a conclusion being made.

Recommendations

The research study has generated several important recommendations related to resource provision, timetabled lesson time for practical lessons, and teacher continuous professional development.

Resource Provision

The study has highlighted a significant issue with the inadequacy of resources, particularly in terms of science laboratories and materials, in schools across the Oshikoto Region. To address this, it is recommended that the Oshikoto Regional Council, through the Directorate of Education with the Ministry of Education, Arts, and Culture (MoEAC), should allocate sufficient funding for the construction of well-equipped science laboratories in both rural and urban schools. These laboratories should cater to learners from the primary levels, allowing them to engage in practical work early in their educational journey. The renovation of existing laboratories is also crucial to provide an ideal environment for practical activities. Furthermore, it is suggested that the MoEAC introduce compulsory practical science examinations as a formal assessment from Grade 8 to motivate teachers to involve learners in practical activities and better prepare them for future assessments. In the absence of traditional laboratory materials, teachers are encouraged to use improvised resources creatively.

Timetabled Lesson Time for Practical Lessons

Given the practical-oriented nature of Physical Science, the study recommends revising the Namibian Curriculum for Basic Education (NCBE) to allocate more teaching time to practical work within the Natural Sciences learning area. Currently, this allocation is only 9% of total teaching time, consisting of five 40-minute lessons per cycle. Increasing the time dedicated to practical work will enable teachers to effectively engage learners in hands-on learning.

Teacher Continuous Professional Development (CPD)

The study underscores the importance of teacher training and professional development, especially in the context of facilitating practical work and classroom organization. Teacher training institutions are advised to incorporate modules on facilitating practical work into their curricula, targeting novice and preservice teachers. Additionally, for practicing teachers, it is recommended that advisory services, in collaboration with experienced science teachers, conduct in-service CPD training. These programs should focus on teaching practical work using locally available, cost-effective materials when traditional laboratory equipment is lacking. Furthermore, it is crucial to engage teachers in CPD activities to enhance their understanding of constructivist teaching and learning approaches, particularly the significance of prediction in knowledge construction. Classroom organization strategies that promote cooperative learning, such as pair, peer, and group work, should also be emphasized during CPD sessions to enhance the effective implementation of practical work in science classrooms. By addressing these recommendations, the educational system in the Oshikoto Region can significantly improve the quality of science education.

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