



Exploring the Status and the Utilisation of Biology Laboratories in a Secondary School in Namibia

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Abstract

As STEM agendas continues to rise, well-equipped functioning science laboratories are essential resource inputs for teaching and learning science and subsequently realizing the STEM agendas. This study is part of a series of projects driven by the continuous poor performance in Biology Senior Secondary Certificate Examination (SSCE) paper 3; which is a practical oriented paper. In particular this study aimed at exploring the use of Biology Laboratories in Namibia Secondary Schools mainly to understand the utilization of laboratory facilities, as well as its implication on the performance of learners in final examination. The study employed quantitative research approach through survey research design. The data was collected from questionnaires that were completed by 104 randomly sampled participants which included the Biology learners, the two school Biology teachers, a principal and a HoD of science education. The questionnaires were triangulated through lessons non participant observation. The study finds a low extended usage of laboratories facilitates contributed by lack of chemicals and apparatus required for effective practicals. Biology practical works in secondary schools did not follow the learning objectives outlined in the prescribed national Biology syllabus as a result some practical topics which required practical works were taught theoretically. While the study finds the use of labs is a worthy aim, the pressure to improvise for the shortages of apparatus is unbearable for the teachers. The inadequate laboratory facilities will continue to hinder meaningful teaching and learning in secondary schools and subsequently catalyze the persistent poor performance of students if the government does not intervene.

Subject Areas

Education Administration

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Keywords

Utilization, Laboratory, Facilities, Biology, Practical Works, Namibian Secondary Schools

1. Introduction

As STEM agendas continue to rise, well-equipped functioning science laboratories are essential resource inputs for teaching and learning science and subsequently realizing the STEM agendas. There is substantive empirical evidence that echoes that Science laboratory is a very vital resource input for teaching science [1]. [1] justifies that laboratory activities stimulate students' interest as well as develop their scientific skills. Practical work has been defined as an experiment performed by the teacher for demonstrations, or series of experiments and observational exercises carried out by the students to relate theoretical knowledge with practical activities done in the laboratory. One of the most effective vehicles by which the process of inquiry can be learnt is the laboratory where the student experiences first hand and the inquiry process. Thus, the study in a laboratory is an integral and essential part of a biology course. Biology laboratory activities are hands-on experiences that emphasize process skills [2] which [3] posited as motor skills that help the scientists to find answers to problems and enhance the learning of science. Laboratory activities also encourage students to construct knowledge by interacting with laboratory materials as they solve problems.

[3] further opined that it is very necessary that students manipulate materials and be equipped in learning of biology through equipment; this will help them not only to acquire science process skills and new knowledge but, also scientific attitude such as honesty, open-mindedness and cooperation as moralities of science and enhance understanding and retention of difficult concepts and procedures. Laboratory facilities give students some basic insight into scientific concepts and leave them with feeling of the reality of science which in turn improves their academic performance in examinations. [4] concludes that the availability of equipped laboratories is the predictor of academic achievement of students; therefore, implying that schools with lack or insufficient laboratories yield poor academic performances.

In most African states including Namibia laboratories have received little attention as reported by [5] in comparison to Western education systems in terms of practice and worse with research and publications. This is saddening because both teachers and learners may be deprived of that of a valuable experience. Therefore, the study was conducted as a series of project to find out the utilization of laboratory facilities and their implication in the performance of students in Biology Senior Secondary Certificate Examination (SSCE) in Namibia.

2. Statement of Problem

Consecutive Ministerial reports of Education [6] and the Examiners' Reports for (NSSCO) on Biology paper 3 continues to show a moderately low performance in comparisons to paper 1 and 2 and other subjects in general across the country and most especially in Rural areas. The Examiners' Report further pointed out that all in all, candidates must be exposed to enough practical activities to broaden their knowledge of this component. Hence, this study was necessary to close the gap how schools are utilising the laboratory facilities for teaching and learning and in preparation of paper 3. Literature shows that the school laboratories are a great place for students which help them enhance their learning by understanding the theoretical concepts of science which are taught in classrooms of which they are assessed on. Well-designed and equipped laboratories not only make science experiments interesting, but also help students in achieving good academic results.

3. Objectives

The study main objective is to investigate the use of laboratory facilities and the impacts on students' academic performance at senior secondary school Biology examinations in Namibian schools; with the following sub objectives.

- 1) To what extent do teachers and students make use of the available Biology laboratory facilities in Namibia?
- 2) What are the factors affecting the use of Biology laboratory facilities in Namibia secondary schools?
- 3) What attempts have been made to address the challenges in laboratory to improve learners' performance in Namibian secondary schools?

4. Research Methods and Techniques

The study used quantitative method of data collection. Descriptive survey research design was therefore employed using self-designed questionnaire and the guiding principles included; the clear, unambiguous, comprehensible language and not suggestive similarly the order of questions was considered.

Survey is the appropriate method to enable the researcher to describe and assess the implementation of practice science laboratory activities in schools. In addition, the research design complimented the ongoing Covid-19 pandemic, since the government of Namibia restricted face to face consultations. The school was purposively chosen from the list of underperforming schools in Biology Paper 3. A sample of 100 grade 11 learners where randomly taken from the learners who had none to five minimum days of absenteeism to remove any other possibilities of other factors contributing to poor performance. The study also included all two Biology teachers, the Head of Department of Science and principal of the school and therefore totaled up to 104 participants. The design enabled the researcher to compare the responses from these participants in examining the present situation and identify some of the major problems in the

area of the study. Moreover, the study observed ten Biology lessons to triangulate the data. The study followed all research ethics such as ethical clearance from the University—(IUM), permission from the regional Director of Education, school principal and all participants involved. Similarly, the permission to take photographs presented in the study was granted. The collected data was analyzed with Microsoft Excel using descriptive statistics using measures of frequency of count, percent, frequency and measures of central tendency such as mean and mode.

5. Materials

5.1. The Significance of Biology Practical Work

The review of literature shows an evolution of practical work and this is evident on how it is understood and perceived across, and this is noticed by [7] as well. Practical work centers learning, hence there are theories of learning that justify how learners can learn through practical experiences. In addition, the role of the teacher in the process has been redefined over time. The new understanding is that teachers teach and teaching of practical work facilitates learning rather than to be a source of all knowledge in the classroom [8]. Teaching practical work involves creating, enriching, maintaining and adapting instruction to achieve the objectives of the subject, capture and sustain interest and engage learners building biological and physical understanding, engaging learners in the process of science that have been systematically tested and shown to reach diverse learners [7].

[9] proposed that appropriate teaching and learning methods in science, such as group work, laboratory investigations and problem-based teaching, allow learners to interact and help each other to attain better subject understanding and achieve practical skills. The use of different teaching methods is likely to accommodate different individual learning styles among the learners.

In addition [9] argue that the teachers' commitment to constructive learner methods does not mean that all the practical skills are achieved with such methods, but that the choice of teaching methods should depend on the objectives of a practical lesson to be covered, the resources and time available. Despite the Namibian curriculum paradigm of constructivism that encourages learner-centred learning approach other than teacher-centred and therefore against the teacher giving a lecture. [10] studies reports to have found Namibian senior secondary school's teachers mostly use the lecture method which does not give learners opportunities to interact and enhance their understanding during practical.

5.2. Factors Affecting the Use of Biology Laboratory Facilities and Strategies often Used as Remedials

Despite that desire and the redefined role of teacher in the usage of the laboratory facilities, there are factors that intervene in the decisions to use the facilities.

These factors range and are contextual. [10] identified that the lack of resources in schools affects learners' performance in Biology. There is a lack of resources such as laboratories and laboratory equipment as well as other teaching aids. Teachers use their classroom for practical work in some instances. In cases where classrooms are used, [10] schools that their experience problems with lack of equipment and chemicals in the laboratories and some equipment in the laboratory broken.

Furthermore, [11] points out that most Namibian secondary school science teachers find it difficult to teach practical work due to lack of laboratories, thus forcing teachers to teach using demonstration methods rather than experiments in teaching practical work.

In some schools, teachers are unable to apply different teaching methods, due to factors, such as the unavailability of chemicals, equipment, apparatus and laboratories.

In addressing the challenge of the laboratory's experiments, Biology teachers of some schools having more laboratory chemicals assist others with critical needs. As a result, teachers look for assistance from the nearby school or other schools in the same cluster. Also, revealed that some Biology teachers improvise on the limited resources that are available and sometimes they device their own teaching materials. This literature is limited and time is of significance hence a need to assess against the above literature.

6. Theoretical Framework

This study is based on the understanding that a high quality science education in secondary schools contributes to developing scientific literacy and would be expected to predispose learners to study the enabling sciences at university [12]. Practical activities are essential in all level of science education and in particular it is highly significant in secondary schools to help learners in internalizing and understanding the theoretical knowledge of science fields such as Biology. To accomplish the goal of practical activities in science, the equipment and experiments have to be carefully selected to give learners a relevant experience and also the understanding is enhanced if the activities are coming from the daily life of the students. Specifically, inquiry-type laboratories have the potential to develop learners' abilities and skills such as posing scientifically oriented questions, forming hypotheses, designing and conducting scientific investigations, formulating and revising scientific explanations, and communicating and defending scientific arguments [13]. Only theoretical teaching for science subjects is not effective. Therefore, it should encompass a combination of instructions, accompanied by practical demonstrations and range of laboratories activities.

The humanistic and constructivist approaches to education, which emphasize that learning occurs naturally, include David Kolb's theory of Experiential Learning. Kolb proposed that experience was critical in the development of knowledge construction, as learning occurs through discovery and active par-

ticipation. Kolb defined leaning as the process whereby knowledge is created through the transformation of experience [13].

There are two parts to Kolb's Experiential Learning Theory. Learning follows a four-stage cycle. Kolb believed that, ideally, learners progressed through the stages to complete a cycle, and, as a result, transformed their experiences into knowledge. Completion of all stages of the cycle allows the transformation of experience to knowledge to occur. Kolb's entire theory is based on this idea of converting experience into knowledge. With each new experience, the learner is able to integrate new observations with their current understanding. Experiences are central to Kolb's theory, as he viewed it as a process by which something must be changed or transformed. Memorization or recollection of ideas taught does not equal learning, as no value has been added to the learner. Kolb's model acknowledges that something must be generated from the experience in order for it to be defined as learning. Kolb's Learning Cycle is based on the Jean Piaget's focus on the fact that learners create knowledge through interactions with the environment [13].

7. Findings and Discussions

Results from the questionnaires

Research question 1: To what extent do teachers and students make use of the available Biology laboratory facilities in Namibia (The usage of laboratories) ?

According to **Table 1**, 95% of instructors and students were unsatisfied with the availability of the current laboratory facilities in their schools, while 5% were satisfied. As a result of this insufficiency, both teachers and learners agree that there is less practicals conducted as prescribed, adding that most practicals teachers rather uses their normal classes for teaching practical work.

Table 1. Usage of laboratory facilities by Teachers and Learners.

	Percentage (%) Disagree	Percentage (%) Agree
1) Presence of Laboratory Technician in School.	100	0
2) Are you satisfied with the number of laboratory facilities at your disposal?	95	5
3) Do you improvise for laboratory facilities at your school?	73	27
4) Do laboratory technicians/teachers get regular training on laboratory activities?	100	0
5) Laboratory well equipped with chemicals and apparatus.	59	41
6) Laboratory technicians/teachers training.	100	0
7) How often do teachers carry out practical work for Biology?	13	87
8) How often do teachers carry out practical work for Biology? In all the practical topics.	13	87
9) We use a Lab to carry out Biology practical work?	24	76
10) We use a Class to carry out Biology practical work?	75	22
11) Quality of Biology laboratory buildings and furniture in school?	50	50

The school lacks the chemicals/reagents and apparatus required for most research, with 51% of participants citing the need for to purchase chemicals and apparatus for the school. Furthermore, the survey discovered that the school has no Laboratory Technician, only biology teachers who assist with practical work and who have never undergone training, as shown in **Table 1**, with 100% of the teachers indicating that the lab needs a technician.

The researcher observed that in most of the experiments, the teacher was demonstrating to the students rather than allowing them to experiment. This demonstrates that learners are not exposed to a diverse range of real-world experiences, which may have influenced their performance.

Research question 2: What is the learner-based, teacher-based and school-based factors affecting the use of Biology laboratory facilities in Namibia secondary schools?

Table 2 shows the mostly the school-based factors which are lack of chemicals, equipment, apparatus and laboratories availability in school has the highest rate 100% as factors that affect laboratory activities in secondary schools. While the teacher factors such as; The lack of appropriate laboratory time/schedule for teachers rate the second highest with 75%; Teacher's lack of training rates third highest with 50%.

While the learner based factors included; Learners lack of effort and interest in laboratory activities and the classroom learning environment rates the lowest with 25%. This implies that the major factors that affect teachers' performance in practical activities were more of school-based factors such as lack of chemicals, equipment, apparatus and laboratories availability in school and lack of appropriate laboratory time/schedule.

The findings from the survey supports the data collected through observation; The quality of Biology laboratory buildings and furniture in school was poor. Similarly, the researcher observed that laboratory facilities, e.g., apparatus were insufficient. The observation results further revealed that laboratory safety wears e.g. lab coat, First Aid Box and supply of chemical reagents were insufficient and unavailable. The laboratory was not well organized in a tidy way and had no enough space that allows learners to move freely. The classrooms are not inviting or motivating for learners to learn. There is nothing interesting in the laboratory and this tends to psychologically affect capabilities of the brain.

It was observed that school had poor laboratory facilities, inadequate supply of chemical reagents and the quantity of textbooks for learners where the practical work manual is written was inadequate as seen by the researcher.

It was also observed that the laboratories have unlabeled and expired chemicals and thus could not be used to perform experiments. It is apparent from the observations that the lack of laboratory equipments, apparatus and chemicals made it difficult for some Biology teachers to teach practical work in the study area.

Figure 1 depicts the only Lab apparatus and equipment, as well as chemicals that are currently available in the lab.

Table 2. Factors affecting the usage of laboratory facilities.

Description	Percentage (%) Agree	Percentage (%) Disagree
1) Lack of appropriate laboratory time/schedule.	25	75
2) Teachers lack of training.	50	50
3) The classroom learning environment is conducive for learning.	25	75
4) Lack of chemicals, equipment, apparatus and laboratories availability in school.	0	100
5) Learners lack of effort and interest in laboratory activities.	25	75
6) Lack of chemicals, equipment, apparatus and laboratories availability in school.	0	100
7) Quality of Biology laboratory buildings and furniture in school.	50	50

**Figure 1.** The availability of apparatus and chemicals or reagents in the school Biology laboratory.

Research question 3: What attempts have been made to address the challenges in laboratory to improve learners' performance in Namibian secondary schools?

Table 3 has shown the possible attempts that have been made to address the challenges in laboratory to improve learners' performance in Namibian secondary schools, such as carry out laboratory activities in the form of theory teaching. Teachers state that when facilities are unavailable, hence 73 percent of teachers opt for theory teaching; and only 27 percent of these teachers improvise for laboratory facilities, such as using films. Additionally teachers agree that 100% that they request the learners to come with materials from home to assist such as bottles to mix chemicals when needed.

8. Discussions

Theme 1: The extent to which teachers and learners make use of available Biology laboratory facilities.

The findings projected in **Table 1** show that there is a minimal usage of the practical classroom which is being referred to a lab. This is evident because practical work was not carried out in all practical topics. These findings are in line

Table 3. The possible attempts and solutions to challenges in laboratory.

Description	Frequency Agree	Percentage (%) Disagree
1) In the absence of resources such as chemicals or apparatus, I opt for Theory Teaching.	73	
2) In the absence of resources such as chemicals or apparatus, I opt for videos.	27	
3) Learners come with materials from home if there are chemicals or reagents?	100	0

with [14] stated that teachers only conducted the practical work when the syllabus says so and they never took it as a teaching strategy on its own. This articulates that learners are learning through listening and observation instead of experiencing learning on their own as there is a lack of practical work in schools. In addition, [15] stated that the practical that are supposed to be done are stated in the Namibian Senior Secondary Certificate for Ordinary Level Biology syllabus for each topic. That is why all teachers were supposed to do practical work because practical have been prescribed in the Biology syllabus.

Despite the STEM objectives, from the results, it is clear that some teachers still use labs to demonstrate rather than assigning pupils to conduct experiments on their own. As these examples indicate and pupils observe, teachers are still considered as sources of knowledge and understanding. As [15] cites, education around the world has developed from a teacher-centered learning transforming into a student-centered learning that teaches students how to take responsibility for their own learning and become more independent. However, our findings show otherwise. The results confirm philosopher Paulo Freire's banking notion, also it reflects the supremacy and power of instructors over knowledge generation. These findings support [15] as he argues that many teachers still follow traditional practices such as direct lecturing, strict use of textbook as the only reference, and rarely extend their teaching to make it relevant to real-life scenarios.

Theme 2: The factors affecting the use of Biology laboratory facilities.

It seems that the availability of the laboratory equipment and resources are some of the challenges facing teachers teaching NSSCO Biology in preparing learners to perform well academically. Some teachers seem to experience a challenge lack of resources and they only allow learners to carry out practical when resources are available [16]. The participants expressed concern about the availability of teaching and learning resources for practical work. The results have shown that participants were not satisfied with the number of laboratory facilities at their disposal. It would appear that the secondary school involved in the study did not have enough resources in their science laboratory.

The lack of equipment's pointed out by the participants correlate with my observation findings as only found two measuring cylinders for the whole school. [15] stated that, most of the Namibian secondary schools have inadequate resources particularly in their science laboratories for teaching practical work. All the teachers and more than 50% of learners have indicated that their secondary school laboratory did not have all the resources for teaching practical work (see

Table 2). These findings have shown consistent with the practical lesson's observations conducted by the researcher (see **Figure 1**), which also revealed that the laboratory for the secondary school that participated in the study did not have adequate facilities for teaching practical work.

[11] argued that the unavailability of teaching materials, such as apparatus and chemicals, have negative effects on the teaching, which might suggest that the teaching of practical works is constrained in secondary schools where there are inadequate laboratory facilities. Also [17] reported that the availability of teaching resources is important for effective teaching to take place. He added that teaching cannot take place in the classrooms if basic teaching materials and equipment are not available. This means that if the secondary schools' laboratories are not well-equipped, it might be difficult for teachers, particularly for Biology to teach practical work. Furthermore, [16] established that lack of practical work leads to poor performance of the learners in the practical examinations.

Theme 3: Attempts made to address the challenges in laboratory to improve learner's performance.

Moreover, it is not surprising then that (95%) of the teachers and learners were not satisfied with the availability of laboratory facilities in their schools as revealed in **Table 1**. In **Table 2**, the least percentage of the teachers and learners (27%) were found to resort to improvisation of the facilities as a way out which is in line with the findings of [18] who reported the participation of teachers in the improvisation of laboratory facilities in the secondary schools.

The study participants indicated that they used theory teaching and practical videos in their teaching of practical works. In **Table 2**, (75%) of the teachers indicated that in the absence of resources such as chemicals or apparatus practical works are presented in the form of theory while 25% use practical videos instead. These findings were consistent with the practical lesson observations conducted by the researcher, which revealed that the teaching methods used by the Biology teachers in practical lessons included both theory teaching and practical videos. Research indicates that the practice of presenting content through lecture method does little to foster constructive learning [12]. This way of teaching may disadvantage the learners because it minimizes social interactions among the learners. Constructive teaching requires learners to build on their prior knowledge at their own pace, flowed by group work. Group experiments are believed to be the heart of social constructivist [12].

Therefore, there are given the study arguments. This implies that the availability of laboratory facilities will positively enhance meaningful teaching and learning that will translate into better performance of students in Biology paper 3 in secondary schools. This may also involve a number of some unstated factors.

9. Conclusions and Recommendations

The study investigated the use of Biology laboratories for practical work in secondary schools in Namibia. The Information gathered from questionnaires and

practical lessons observation clearly demonstrates that the Biology teachers rarely carried out practical work. The teachers also did not provide opportunities for the learners to carry out practical works themselves even though learners were expected to do practical works under the guidance of the teacher. The findings of the study revealed that there were inadequate facilities in the Biology laboratories in the senior secondary schools in Namibia. Based on the findings of the questionnaire and observation guide there also is a significant relationship between the availability of laboratory facilities and the performance of students in the SSCE. It can then be concluded that inadequate laboratory facilities hinder meaningful teaching and learning in secondary schools and contribute to the persistent poor performance of students in the SSCE in Khomas region and possibly countrywide.

Based on the research findings and conclusion, the following recommendations are made:

- 1) In order to each Biology practical work appropriately it is recommended that the teachers teach practical work according to the guidelines in the subjects' curricula and should address the specified objectives.
- 2) In order to help Biology teachers in the assessment of practical skills acquired by the learners, training workshops for the teachers should be held on a regular basis to train them on how to design practical activities and conduct practical work.
- 3) The researcher observed that the secondary school have a shortage of resources (e.g. chemicals and apparatus). Therefore, the Ministry of Education, Arts and Culture should provide adequate resources that are needed during practical lessons for better learning of practical work.
- 4) The government must give great attention to school laboratory buildings, laboratory equipments and chemicals/reagents.
- 5) In the absence of standard laboratory facilities, improvisation should be encouraged and used which may provide the opportunity for creativity and innovations in both the teachers and students.

Authors and Affiliations

IUM

Conflicts of Interest

The authors declare no conflicts of interest.

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