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Research Article

Exploring the efficacy of practical work on learners' academic achievements in biology at senior secondary level in Namibia

Fredrick S. Simasiku [1]*, Rauna Amadhila [1], Rikuvera Tjizera [1], Tomas Shivolo [1]

[1] School of Secondary and Postgraduate Education, The International University of Management, Windhoek, NAMIBIA
***Corresponding Author:** f.simasiku@ium.edu.na

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ABSTRACT

This study examines the impact of practical laboratory work on the academic performance of senior secondary biology learners in the Khomas Region Namibia. Employing a quantitative research approach, data was collected from four purposively selected schools. Data were collected through document analysis of the four schools of with two schools were fully furnished with science laboratory and the other two lacked science laboratory. Descriptive statistics were employed to analyze quantitative data. The findings indicate a notable influence of laboratory exposure on academic performance of learners in understanding science concepts, with learners who have access to laboratory facilities demonstrating higher levels of achievement. However, it was also observed that even learners without laboratory access strive to excel by diligently grasping theoretical concepts. Recommendations drawn from this study include advocating for the establishment of laboratories in schools lacking such facilities, as well as encouraging collaboration between schools to facilitate access to laboratory resources. This study underscores the importance of practical work in biology and calls for concerted efforts to ensure equitable access to laboratory resources for all learners.

Keywords: practical work, biology, laboratory, Namibia, academic achievement

INTRODUCTION

The exploration of practical work's impact on learners' academic achievements in biology at the senior secondary level in Namibia is crucial given the recognized deficiencies in hands-on activities within scientific education. As highlighted by Dike (2009), reliance on textbooks among science teachers is prevalent, potentially hindering effective learning experiences. This study aims to address this gap by examining the effects of practical work on learners' academic performance within the context of biology education in Namibia's senior secondary schools. By investigating how hands-on activities can be integrated into teaching practices, utilizing the available resources in the Khomas Region, this research seeks to shed light on effective pedagogical strategies to enhance learners' understanding and achievement in biology. It is revealed that practical work is underutilized by teachers in Namibian science classrooms despite its potential to enhance learners' academic achievements due to contextual access issues teachers in Namibia are phased with (Shivolo & Mokiwa, 2024). With a prevalent reliance on textbooks among science teachers, there is a pressing need to investigate the impact of integrating practical work into teaching methodologies. Namibian teachers have a strong advocacy for engaging learners in science practical work, however, challenges such as lack of resources to facilitate practical work, overcrowded classrooms, less timetable time for practical lessons inhibit such preference (Shivolo & Mokiwa, 2024). Despite the availability of resources at some schools within the Khomas Region, the effective implementation of hands-on mind-on and word-on activities remains uncertain, particularly in science subjects (Asheela et al., 2020). Therefore, this study aims to address this gap by exploring how practical work influences learners' academic performance in biology, identifying the challenges and opportunities associated with its integration, and proposing strategies to optimize its effectiveness within Namibia's Senior Secondary education system.

It is anticipated that the results of this current research hold significance for both immediate and long-term stakeholders in education, offering insights into the correlation between laboratory exposure and learners' achievements in biology. By highlighting the importance of practical engagement alongside theoretical understanding in science education, this study has the potential to reshape perceptions within the academic community. Through the effective utilization of these findings, biology learners stand a chance to gain invaluable hands-on experience, thus enhancing their performance in biology paper 3 (an examination question paper at the Namibian senior secondary certificate ordinary [NSSCO] level in Namibia, which assess learners' exposure to experimental and investigative skills). Furthermore, the findings from this study may prompt the Ministry of Education, Arts, and Culture (MoAEC) to recognize the pivotal role of laboratory exposure in the success of Namibian biology learners, leading to the provision of necessary facilities, equipment, and materials to adequately support biology teachers and learners alike.

Based on these assumptions, the following research questions have been set to provide a focus for the study:

1. How does laboratory exposure influence learners' academic performance in biology?
2. What disparities exist in the academic performance of learners who have access to laboratory equipment and those who do not within the Khomas Region?

LITERATURE REVIEW

Biology Curriculum in Namibia

Drawing from the MoEAC (2021), report on the examination NSSCO, the overarching objective of this curriculum is to nurture well-rounded learners who are not only drawn to practical and experimental work in biology but also develop skills applicable to their daily lives and broader societal contexts. Through exposure to meticulously planned and executed practical sessions and experiments, learners cultivate environmental consciousness, a passion for nature, and a heightened awareness of precision, hypothesis formulation, and accuracy (Quay & Seaman, 2013). This holistic approach to education lays the foundation for various career paths, including but not limited to doctors, nurses, environmentalists, scientists, engineers, and frontline workers. The implementation of biology curriculum was a challenge to the teachers that lack pedagogical content knowledge and content knowledge (Aloovi, 2016; Hamunyela et al., 2022). Hambabi et al. (2024) deduced that the lack of teacher competency and lack of biology exposure especially to practical works demotivates learners to study and understand biology due to learners' insufficient background knowledge of the subject. Adding to this Aloovi (2016) looked at the perceptions of teachers when using the lived experiences that learners and teachers gained from home. Biology teachers struggled to connect lived experiences and scientific knowledge documented in the textbooks.

Furthermore, as highlighted by Tordzro et al. (2021) initial exposure to experimental hypotheses and the conceptual framework of significant findings deepens learners' understanding of scientific principles. Analyzing well-established scientific papers provides learners with insights into scientific inquiry at its finest, prompting critical questions such as the design of experiments, the motivations behind studies, and the impact of discoveries on the trajectory of science. Engaging with scientific literature not only fosters an appreciation for the culture and history of science but also underscores the collaborative and progressive nature of scientific endeavors, transcending temporal and spatial boundaries (MoAEC, 2021).

Practical Work in Science Education

Practical work has emerged as a cornerstone of scientific education globally, notably gaining momentum that could help learners understand the concepts in biology (Shivolo, 2024; Tordzro et al., 2021). Its primary objectives encompass fostering a genuine appreciation and insight into the study of natural and physical phenomena, bridging the gap between learners and the realities encountered by researchers in these fields, while also correlating with academic success (MoEAC, 2021). However, despite these aspirations, practical work has encountered challenges in achieving its intended outcomes, as noted by (Tordzro et al., 2021). To address this, a systematic literature review has been proposed to comprehensively explore practical work in science pedagogy, focusing on its conceptualization, critiques, evaluation methods, and benefits.

Defining practical work in science involves any educational activity that cultivates precision, accuracy, manipulation, and observation skills among learners, facilitating critical thinking and contextual understanding (Tordzro et al., 2021). It serves as a catalyst for hypothesis formulation and the honing of critical thinking abilities. Notably, practical learning has been associated with advancements in hands-on experimentation, rapid adaptability, and proficiency in laboratory techniques, as highlighted by the MoEAC (2021).

Practical Work in Biology

Practical work in biology education is an integral component of science learning, providing learners with hands-on, mind-on and word-on experiences that enhance their understanding of theoretical concepts (Asheela et al., 2020). Numerous studies have investigated the efficacy of practical work in biology, highlighting its positive impact on learners' engagement, conceptual understanding, and skill development. For instance, research by Abrahams and Millar (2008) emphasized the role of practical work in fostering scientific inquiry skills, such as observation, hypothesis formulation, and data analysis, which are essential for scientific literacy. Similarly, studies by Hofstein and Lunetta (2004) and Bennett and Lubben (2006) underscored the significance of practical activities in promoting deeper conceptual understanding by enabling learners to connect theoretical knowledge with real-world phenomena.

However, challenges exist in implementing effective practical work in biology education. Issues such as time constraints, resource availability, and safety concerns often hinder the quality of practical experiences for learners (Cheung, 1992; Shivolo, 2024; Woodley, 2009). Moreover, the assessment of practical work remains a complex task, as traditional evaluation methods may not adequately measure learners' mastery of both theoretical knowledge and practical skills. To address these challenges, teachers have explored innovative approaches, including the integration of technology-enhanced practical activities and the adoption of inquiry-based learning strategies (Kim et al., 2007; Little, 2008). For instance, formative assessment techniques, such as peer assessment and self-reflection, have been advocated to provide more holistic evaluations of learners' learning outcomes (Millar, 2004). Despite these challenges, practical work continues to play a crucial role in biology education, offering learners valuable opportunities to engage with science in meaningful ways.

Benefits of Practical Work

Practical work in education has long been recognized as a cornerstone in fostering meaningful learning experiences across various disciplines. Researchers such as Hofstein and Lunetta (2004) have highlighted its pivotal role in science education, emphasizing how hands-on activities promote deeper conceptual understanding and engagement among learners. Through direct interaction with materials and phenomena, learners can develop critical thinking skills, enhance problem-solving abilities, and cultivate a sense of curiosity and inquiry (Abrahams & Millar, 2008). Furthermore, practical work provides opportunities for learners to develop essential laboratory skills, including experimental design, data analysis, and scientific communication, thereby preparing them for future academic and professional endeavors (Linn et al., 2015). Furthermore, practical work has been linked to increased motivation and engagement among learners, as it offers tangible outcomes and real-world applications of theoretical concepts (Chamany et al., 2008).

Numerous studies affirm the benefits of incorporating practical exercises in teaching and learning processes at the senior secondary level of science education. Practical work serves as a motivational catalyst for learners, igniting interest while refining proficiency in laboratory techniques and scientific knowledge (Nghipandulwa, 2011). It provides avenues for enhancing comprehension through hands-on experimentation, fostering critical thinking skills, and nurturing hypothesis formulation abilities (Asamoah & Aboagye, 2019).

Furthermore, practical engagement extends beyond equipment utilization, encompassing various alternative learning methods such as teacher demonstrations, peer collaborative problem-solving, discussions, and learner-teacher interactions (Nghipandulwa, 2011). These interactive approaches not only deepen learners' understanding of concepts but also stimulate interest in learning, promoting a learner-centered approach. Overall, the incorporation of practical work across disciplines not only enriches learning experiences but also equips learners with the diverse skills and competencies needed to thrive in an ever-evolving global society.

Challenges in Integrating Practical Work

Practical work in secondary education faces a myriad of challenges, primarily stemming from resource constraints. Studies by Glover (2013) and Ibrahim (2021) highlight the significant cost associated with essential resources for practical work, such as laboratory equipment and instructional materials, which often dissuade schools from integrating laboratory work into their teaching processes. This sentiment is echoed by the findings of Nghipandulwa (2011), Kaupitwa and Amuthenu (2022), and Kandjeo-Marenga (2023), indicating that the scarcity of laboratory facilities and appropriate apparatus remains a prevalent issue in Namibian secondary schools, hindering the implementation of practical work.

Moreover, the omission of practical work, compounded by limited time allocations for such exercises, poses further challenges to its inclusion (Shivolo, 2024). There is a prevailing tendency among science teachers to prioritize theoretical aspects over practical or laboratory-based activities, as noted by Ibrahim (2021). Nghipandulwa (2011) reported that a substantial percentage of teachers neglect the incorporation of practical work in biology teaching, opting instead for traditional methods that lack real-life relevance. Additionally, deficits in teachers' practical proficiencies and a shortage of qualified and experienced science teachers, as identified by Glover (2013), exacerbate the situation, limiting the effective execution of practical sessions. This is compounded by Kasiyo et al.'s (2017) assertion that teachers' self-efficacy and professional competence significantly impact their ability to confidently conduct practical work. The cumulative effect of these barriers, as predicted by Kandjeo-Marenga (2023), may lead to an increased failure rate in science-based subjects due to insufficient emphasis on practical work and a lack of accompanying teaching and learning materials. Thus, the lack of emphasis on practical work in secondary schools has far-reaching implications for learners' educational outcomes.

METHODS

According to Budert-Waltz (2021), the method through which researchers gather, evaluate, and interpret data is termed as research methodology or approach. Research can be conducted using three distinct approaches: mixed methods, qualitative, and quantitative. In this study, a quantitative approach was adopted. This approach involves gathering and analyzing quantitative data within a single study and data were generated from school schedules of biology papers 3 from four schools in Windhoek, Namibia. A quantitative approach offers a more comprehensive understanding through the analysing of the findings. Given the involvement of multiple senior secondary schools in the Khomas Region in this study, the quantitative approach has been deemed as the appropriate method for the current study to analyze the performance of the learners in practical paper in biology.

Sampling Procedures

The research questions outlined the study's purpose and aims, aiding in the identification of the target population. The study focused on the performance of learners enrolled in biology courses at the senior secondary level within the Khomas Region of Namibia as its target population.

Utilizing a purposively sampling approach (Bertram & Christiansen, 2015), a representative sample was selected from this target population of schools, of with two schools with laboratory facilities and two schools without laboratory facilities were purposefully selected. To gauge academic performance and gather data on learners' academic performance in biology paper 3, data were obtained from documents analysis.

Document Analysis

Document analysis is a powerful research tool employed across various disciplines to collect rich and nuanced data from existing texts, documents, or records (Davie & Wyatt,

Table 1. Biology grade 10 examination result analysis for paper 3 (2023)–School A with laboratory facility

Year of exam	Symbols and their pass rate								Total number of learners
	A (80-100%)	B (70-79%)	C (60-69%)	D (50-59%)	E (40-49%)	F (30-39%)	G (20-29%)	U (0-19%)	
2023	28	25	63	49	45	17	9	6	242

2021). This method involves systematic examination and interpretation of documents to extract valuable insights, patterns, and trends relevant to the research objectives. Bowen (2009) describes a comprehensive approach to document analysis in quantitative research, emphasizing the importance of developing a coding scheme, ensuring inter-coder reliability, and maintaining reflexivity throughout the analytical process. Similarly, Krippendorff (2018) offers a seminal guide to content analysis, outlining various techniques and strategies for analyzing textual data to derive meaningful insights. A document analysis tool was used to collect data from the schedule in four schools. The schedule of the summary where marks for paper 3 were from all four schools was analyzed. Biology teachers helped in summaries of the marks from all the learners for paper 3 biology that allowed us to use only the marks that were obtained in that paper. The focus was practical components of biology, and this guided us to focus only on paper 3

Data Analysis

Data analysis, as defined by Kelly (2023), encompasses the transformation, cleansing, and examination of raw data to extract relevant information vital for research decision-making, often presented through tables, graphs, charts, and images. Descriptive statistics was used to analyze the data that were collected from the schedule for biology paper 3 for 2023 November examination. Data were presented according to the schools where it was obtained. Schools were coded as school A, school B, school C, and school D.

Data Presentation

Data from the analysis of the past examination results (paper 3 for grade 10 biology 2023), as presented in **Table 1**, illustrated the distribution of symbols in all four school A and school B with laboratory facilities and school C and school D without laboratory facilities. The examination result analysis for paper 3 of the biology grade 10 exam at school A with laboratory facilities, depicted in **Table 1**, offers a detailed portrayal of learners' academic performance based on percentage scores and corresponding symbols. In the year 2023, out of the total 242 learners who took the exam, the distribution across the pass rate categories is, as follows: grade A was obtained by 28 learners, representing approximately 11.6% and 25 learners obtained grade B, constituting roughly 10.3%. Grade C were obtained by 63 learners, accounting for around 26.0% and most learners obtained this symbols. Grade D was obtained by 49 learners, making up about 20.2% of the total. 45 learners scored E, comprising approximately 18.6% and 17 learners scored F, representing roughly 7.0% while G 9 learners, constituting about 3.7% of the total. Lastly 6 learners scored U, accounting for approximately 2.5% of the total.

This breakdown highlights the varying levels of achievement among the learners cohort, with the majority falling within the pass rate ranges of C, D, and E. While a notable proportion of learners achieved higher grades (A and B), there are also learners who obtained lower grades (F, G, and U). This analysis underscores the importance of targeted support and instructional interventions to address the diverse learning needs of learners across different proficiency levels. Additionally, it provides valuable insights for teachers to tailor their teaching strategies and curriculum delivery to enhance overall student comprehension and success in biology at school A.

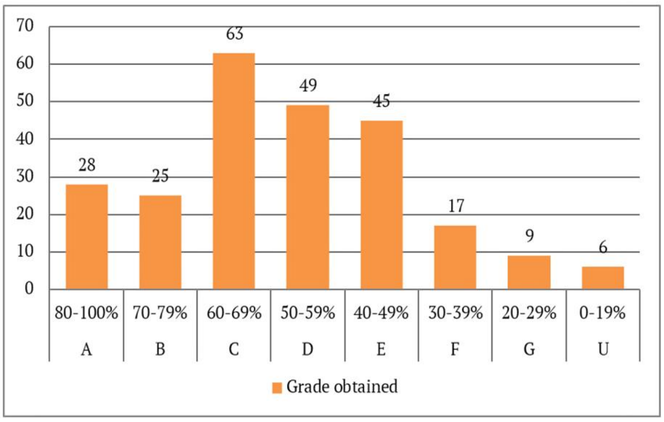

Figure 1. Biology grade 10 examination result analysis for paper 3 (2023)–School A with laboratory facility (Source: Field study - School A November 2023 Schedule Document)

Figure 1 shows biology grade 10 examination result analysis for paper 3 for 2023 academic year, school A with laboratory facility and the symbols that learners have obtained in their final examination, the symbols range from A to U (A, B, C, D, E, F, G, and U). A total number of 28 learners obtained A, 25 managed to obtain B, 63 obtained C, 49 obtained D, 45 obtained E, 17 obtained F, 9 obtained G, and 6 of the learners obtained U symbol. This data suggest majority of the learners obtained the symbols range from B-D (B, C, and D) and minority of the learners obtained the symbols A, F, G, and U.

Table 2 shows biology grade 10 examination results for the year 2023 academic year for school B with laboratory facility. A total of 233 learners wrote their biology paper 3 final examination of which only 32 learners got A, 46 managed to obtain B, 33 got C, 30 got D, 45 got E, and less than 20 learners scored between symbol F and symbol U.

Figure 2 shows biology grade 10 examination result analysis for paper 3 for 2023 academic year, school A with laboratory facility and the symbols that learners have obtained in their final examination, the symbols range from A to U (A, B, C, D, E, F, G, and U). A total number of 32 learners obtained A, 46 managed to obtain B, 33 obtained C, 30 obtained D, 45 obtained E, 18 obtained F, 19 obtained G, and 10 of the learners obtained U symbol. This data suggests majority of the learners obtained the symbols range from A-E (A, B, C, D, and E) and minority of the learners obtained the symbols F, G, and U.

Table 2. Biology grade 10 examination result analysis for paper 3 (2023)–School B with laboratory facility

Year of exam	Symbols and their pass rate								Total number of learners
	A (80-100%)	B (70-79%)	C (60-69%)	D (50-59%)	E (40-49%)	F (30-39%)	G (20-29%)	U (0-19%)	
2023	32	46	33	30	45	18	19	10	**233**

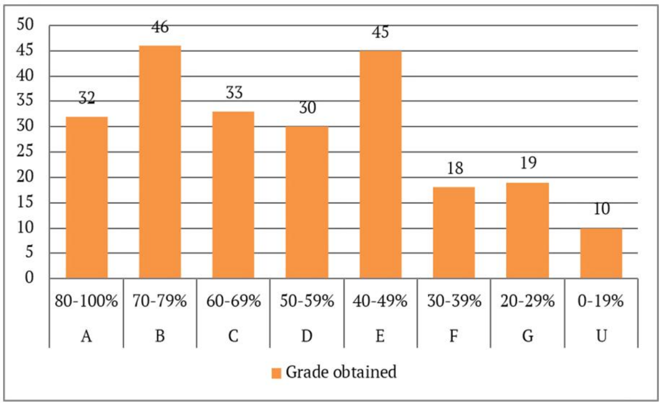

Figure 2. Biology grade 10 examination result analysis for paper 3 (2023)–School B with laboratory facility (Source: Field study - School B November 2023 Schedule Document)

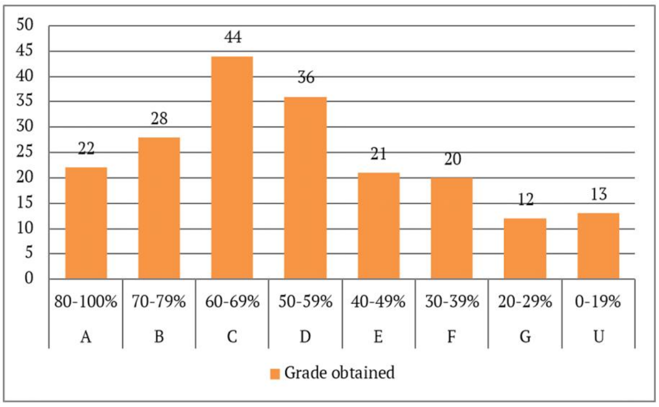

Figure 3. Biology grade 10 examination result analysis for paper 3 (2023)–School C with laboratory facility (Source: Field study - School C November 2023 Schedule Document)

Table 3. Biology grade 10 examination result analysis for paper 3 (2023)–School C with laboratory facility

Year of exam	Symbols and their pass rate								Total number of learners
	A (80-100%)	B (70-79%)	C (60-69%)	D (50-59%)	E (40-49%)	F (30-39%)	G (20-29%)	U (0-19%)	
2023	22	28	44	36	21	20	12	13	**196**

Table 4. Biology grade 10 examination result analysis for paper 3 (2023)–School D with laboratory facility

Year of exam	Symbols and their pass rate								Total number of learners
	A (80-100%)	B (70-79%)	C (60-69%)	D (50-59%)	E (40-49%)	F (30-39%)	G (20-29%)	U (0-19%)	
2023	21	36	38	51	47	41	29	16	**279**

Table 3 shows biology grade 10 examination results for the year 2023 academic year for school C without laboratory facility. A total of 196 learners wrote their biology paper 3 final examination of which only 22 learners got A, 28 managed to obtain B, 44 got C, 36 got D, 21 got E, 20 got F, 12 got G, and 13 of the learners got U symbol.

Figure 3 shows biology grade 10 examination result analysis for paper 3 for 2023 academic year, school C without laboratory facility and the symbols that learners have obtained in their final examination, the symbols range from A to U (A, B, C, D, E, F, G, and U). A total number of 22 learners obtained A, 28 managed to obtain B, 44 obtained C, 36 obtained D, 21 obtained E, 20 obtained F, 12 obtained G, and 13 of the learners obtained U symbol. This data suggest majority of the learners obtained the symbols range from B-C (B, C, and D) and minority of the learners obtained the symbols A, E, F, G, and U.

Table 4 shows biology grade 10 examination results for the year 2023 academic year for school D with laboratory facility. A total of 279 learners wrote their biology paper 3 final examination of which only 21 learners got A, 36 managed to obtain B, 38 got C, 51 got D, 47 got E, 41 got F, 29 got G, and 16 of the learners got U symbol.

Figure 4 shows biology grade 10 examination result analysis for paper 3 for 2023 academic year, school D without laboratory facility and the symbols that learners have obtained in their final examination, the symbols range from A to U (A, B, C, D, E, F, G, and U). A total number of 21 learners obtained A, 36 managed to obtain B, 38 obtained C, 51 obtained D, 47 obtained E, 41 obtained F, 29 obtained G, and 16 of the learners obtained U symbol. This data suggest majority of the learners obtained the symbols range from B-G (B, C, D, E, F, and G) and minority of the learners obtained the symbols A and U.

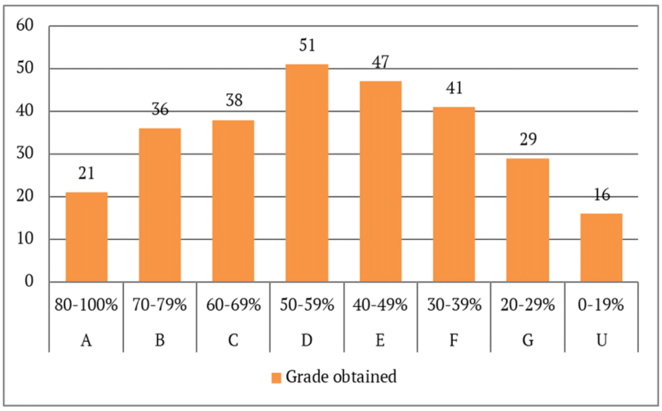

Figure 4. Biology grade 10 examination result analysis for paper 3 (2023)–School D with laboratory facility (Source: Field study - School D November 2023 Schedule Document)

DISCUSSION

Table 5 illustrates the analysis of percentage obtained by four schools per symbols from A to U. **Table 5** presents a comprehensive analysis of the examination results across four different schools, labelled A, B, C, and D. Each school is evaluated based on the percentage of learners falling within

Table 5. Number of symbols and percentage obtain by four schools

Schools	A	%	B	%	C	%	D	%	E	%	F	%	G	%	U	%	Total
A	28	11.6	25	10.3	63	26.0	49	20.2	45	18.6	17	7.0	9	3.7	6	2.5	242
B	32	13.7	46	19.7	33	14.2	30	12.9	45	19.3	18	7.7	19	8.2	10	4.3	233
C	22	11.2	28	14.3	44	22.4	36	18.4	21	10.7	20	10.2	12	6.2	13	6.6	196
D	21	7.5	36	12.9	38	13.6	51	18.3	47	16.8	41	14.5	29	10.4	16	5.7	279

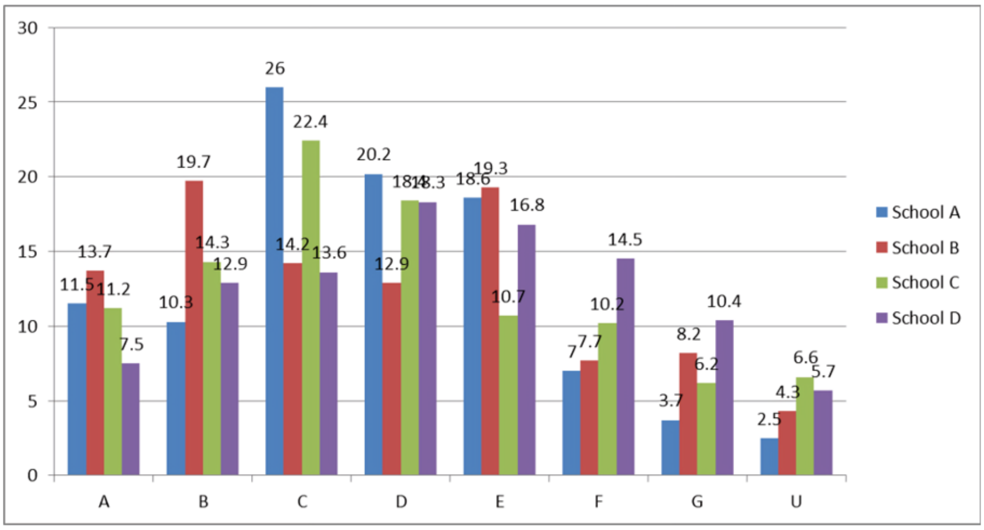

Figure 5. The comparison of schools A-U on the academic performance (Source: Authors' own elaboration)

various grade categories, ranging from A to U, where each grade range represents a specific percentage score. There after these data were transferred to bar as shown below.

School A showcases a diverse performance across different grades. Notably, it demonstrates a strong presence in grade C, with 26.0% of learners achieving this grade, suggesting a robust grasp of the curriculum material. However, there are areas for improvement, particularly in grade D and grade E, where the percentages are 20.2% and 18.6%, respectively, indicating a notable proportion of learners falling below expectations in these subjects. Furthermore, the relatively low percentages in grades F, G, and U (7.0%, 3.7%, and 2.5%, respectively) highlight the need for targeted support or intervention strategies to address weaker areas and ensure a more balanced academic performance.

In contrast to school A, school B exhibits a higher overall percentage of learners achieving grade B (19.7%), indicating a stronger performance in this subject compared to other schools. However, there is a considerable percentage of learners receiving grade U (4.3%), signalling a need for attention to address underlying issues affecting academic outcomes. Additionally, while the percentages in grade C and grade D are relatively balanced (14.2% and 12.9%, respectively), there is room for improvement in grade F and grade G, where the percentages are 7.7% and 8.2%, respectively. Overall, school B demonstrates strengths in certain areas but also areas requiring focused improvement efforts.

School C presents a mixed performance across different grades. It shows a commendable percentage of learners achieving grade C (22.4%), indicating a solid understanding of the subject matter. However, similar to other schools, there are notable proportions of learners receiving grade D and grade E (18.4% and 10.7%, respectively), suggesting areas where academic support may be needed to enhance performance. Furthermore, the percentages in grades F, G, and U (10.2%, 6.2%, and 6.6%, respectively) underscore the importance of implementing strategies to address weaker areas and ensure a more balanced distribution of grades.

School D demonstrates a varied performance across different grades. Notably, it shows a relatively high percentage of learners achieving grade D (18.3%), indicating a solid grasp of the subject material. However, there are areas for improvement, particularly in grade F and grade G, where the percentages are 10.4% and 5.7%, respectively, suggesting a need for targeted intervention to support learners in these subjects. Additionally, the relatively high percentage of learners receiving grade U (10.4%) highlights the importance of implementing strategies to address underlying issues and improve overall academic outcomes.

The results presented in **Figure 5** highlight the performance distribution of learners across four different schools (A, B, C, and D) in biology paper 3, with school A and school B having access to laboratory facilities and school C and school D lacking laboratory resources. School A and school B show a relatively balanced distribution of grades, with varying percentages across different grade categories. Conversely, school C and school D exhibit a more scattered distribution, with different percentages of learners achieving various grades. This divergence in performance between schools with and without laboratory facilities underscores the potential impact of practical work on academic achievement in biology. But there is a distinctive pattern that schools with laboratory access performed better than those without laboratory.

The availability of a science laboratory in schools significantly enhances learners' academic achievements in science practical work, as demonstrated in the current study. The findings from this study align with existing literature, underscoring the fundamental role of well-equipped science laboratories in facilitating hands-on learning experiences that promote deeper understanding and retention of scientific concepts. For instance, Hofstein and Lunetta (2004) highlight that practical work in laboratories fosters an active learning environment, encouraging learners to engage in scientific inquiry and develop essential skills such as critical thinking and problem-solving. Similarly, Millar (2004) emphasizes the importance of practical work in bridging the gap between theoretical knowledge and real-world application, thereby enhancing learners' understanding and interest in science subjects.

Moreover, Abrahams and Reiss (2012) argue that practical work in science education contributes to improved academic outcomes by providing learners with opportunities to apply theoretical knowledge in experimental contexts, thus reinforcing their understanding. The study by Tobin (1990) further supports these findings, demonstrating that learners in schools with well-equipped laboratories perform significantly better in science assessments compared to those without such facilities. Lastly, Osborne and Dillon (2010) assert that the availability of science laboratories and the implementation of practical work are crucial for fostering scientific literacy and preparing learners for future scientific endeavors. Collectively, these scholarly contributions corroborate the findings of the current study, affirming that the presence of science laboratories is instrumental in enhancing learners' academic achievement in biology and other science disciplines. As demonstrated in school A and school B, where laboratory facilities are available, learners have the opportunity to apply theoretical knowledge in a practical context, leading to a deeper understanding of biological principles and better performance in assessments.

On the contrary, school C and school D, lacking laboratory resources, exhibit a less uniform distribution of grades, with potentially lower percentages of learners achieving higher grades. The absence of laboratory facilities may limit learners' exposure to practical applications of biology, hindering their ability to develop critical laboratory skills and apply theoretical concepts in real-world contexts (Linn et al., 2015). Research suggests that practical work stimulates learners' interest and motivation in learning biology, leading to improved academic performance (Chamany et al., 2008). Therefore, the discrepancies observed in school C and school D underscore the importance of providing equitable access to laboratory facilities to enhance learners' learning experiences and academic achievements in biology. **Figure 6** exemplifies the summary of performance in percentage of the four schools looking at A-C. The symbol A-C are recommended by the MoEAC for the learner that goes to grade 12 and university level.

The results indicate that school A and school B, both equipped with laboratories, exhibit comparable performance on the assessment labelled "A-C symbols," with scores of 47.90% and 47.60%, respectively. This observation aligns with existing literature emphasizing the positive impact of laboratory facilities on student learning outcomes, particularly in science and mathematics disciplines (Hattie, 2009; National

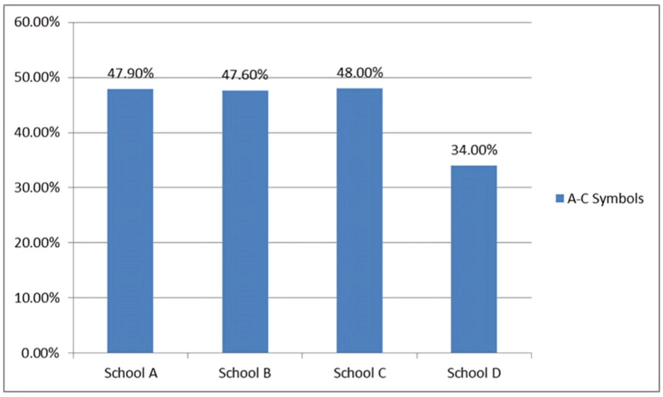

Figure 6. Summary of symbols A-C in four schools (Source: Authors' own elaboration)

Research Council [NRC], 2006). Equally, school C and school D, lacking laboratory resources, demonstrate similar performance levels of 48.00% and 34.00%, respectively. This echoes findings from studies highlighting the disparities in academic achievement between schools with and without laboratory facilities, underscoring the crucial role of hands-on, mind-on and word-on experimentation and inquiry-based learning in enhancing learners' comprehension and academic achievement (Asheela et al., 2020; Hofstein & Lunetta, 2004; NGSS Lead States, 2013). These results underscore the importance of equitable access to laboratory resources in fostering student success across diverse educational settings.

To address these disparities, policymakers and teachers should prioritize the provision of laboratory resources and facilities in all schools, ensuring that every student has access to practical work opportunities in biology education. Additionally, professional development programs for teachers should focus on incorporating effective practical work strategies into the curriculum to maximize its educational benefits (Hofstein & Lunetta, 2004). By investing in practical work in biology education, schools can foster a deeper understanding of biological concepts, enhance learners' scientific skills, and promote academic success for all learners.

CONCLUSIONS AND RECOMMENDATIONS

The literature reviewed underscores the significant positive impact of practical work on learners' academic achievements in biology at the senior secondary level in Namibia. Studies such as those by Hofstein and Lunetta (2004) and Abrahams and Millar (2008) have demonstrated how practical activities facilitate deeper conceptual understanding, critical thinking, and engagement among learners. Furthermore, the development of laboratory skills through hands-on experimentation, as highlighted by Linn et al. (2015), is crucial in preparing learners for higher education and future careers in the sciences. Additionally, the findings suggest that practical work transcends disciplinary boundaries, with benefits observed in mathematics (Sowell, 1989), language learning (Swain & Lapkin, 1998), and beyond (Chamany et al., 2008), indicating its broad applicability across the curriculum.

Based on the evidence presented, it is recommended that teachers in Namibia prioritize the integration of practical work into the biology curriculum at the senior secondary level. This can be achieved through the provision of adequate resources, including laboratory equipment and trained teachers, to facilitate hands-on learning experiences. Additionally, professional development programs for teachers should focus on innovative pedagogical approaches that emphasize inquiry-based learning and experimentation. Furthermore, policymakers should recognize the value of practical work in enhancing academic achievements and consider its incorporation into educational policies and frameworks. By embracing practical work as a fundamental component of biology education, Namibia can empower learners to become critical thinkers, problem solvers, and lifelong learners equipped for success in the 21st century.

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