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STATUS OF BIOLOGY LABORATORY RESOURCES IN ORDINARY SECONDARY SCHOOLS: A CASE STUDY OF MOROGORO MUNICIPALITY, TANZANIA

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ABSTRACT

The availability of biology laboratory resources plays an important role in the success of the practical activities for teachers to carry out their roles in the teaching processes. This study examined the current status of biology laboratory resources in ordinary secondary schools. The study was carried out in seven public and six private ordinary-level secondary schools within Morogoro Municipality, Tanzania. The study involved a mixed method approach and 40 participants, including 13 biology teachers, one laboratory technician and 26 students. We collected data through a questionnaire and structured interviews, then analyzed it using descriptive analysis, chi-square tests, and content analysis. The findings of this study showed a significant difference in the availability of laboratory resources between public and private schools ($\chi 2$ =67.105, df = 2, p = 0.000). 50% of laboratory items were sufficient in both school types, while 33% and 14% were absent in public schools and private schools, respectively. Also, the study shows that practical manuals had a higher deficit than other resources. Additionally, the study identified limited time as the primary challenge to conducting practical activities in public and private schools. We recommend increasing the allocation of laboratory resources to public schools and providing more laboratory time for students in both schools.

KEYWORDS: Biology Laboratory Resources, Private schools, Public Schools, Challenges,

INTRODUCTION

Globally, science laboratories are acknowledged for helping students to apply theoretical knowledge to hands-on experiences through direct interaction with the objects or events being studied and manipulating equipment or materials to address real-world problems (Gobaw & Atagana, 2016). Tuyishime & Tukahabwa (2022) show that teachers use hands-on activities while teaching biology lessons in order to stimulate students' interests and improve learning outcomes. Hands-on activities

provide an opportunity for students to see, feel, touch, identify, and derive meaning from relevant topics (Kibani, 2021). With the rapid pace of innovation in science and technology, students should engage in hands-on and minds-on learning to construct their own knowledge through experience and form a perfect understanding of theoretical science concepts (Niyitanga et al., 2021). Thus, a well-designed science laboratory enhances not only students' understanding of scientific concepts but also increases understanding of the nature of science, develops scientific reasoning abilities and practical skills, cultivates interest in science and science learning, and enhances mastery of science concepts and teamwork abilities (Tordzro & Ofori, 2018).

In Tanzania, biology is one of the mandatory science subjects in the ordinary level secondary education system (Kibani, 2021). The subject encompasses a range of topics, tailored to students' levels of understanding, progressing from simple to more complex concepts. Each topic includes various practical activities designed to enhance students' understanding (TIE, 2012). The goal is to help students recognize and comprehend the connections between themselves, other living organisms, and their environment (Amoah et al., 2023). Practical lessons are a crucial element of biology teaching and learning, and no biology topic can be fully taught without incorporating practical experience (Tordzro & Ofori, 2018). The effectiveness of a laboratory practical is influenced by the availability and quality of resources provided in the laboratory. The biology laboratory resources includes both human and physical resources, such as practical manuals, apparatus, reagents or chemicals, models of tissues and organs, and laboratory buildings with supporting facilities like preparation rooms, workbenches with stools and shelves, and sufficient space for conducting practical (Amoah et al., 2023). Laboratory resources facilitate easier knowledge transmission for teachers and enhance the effectiveness of teaching and learning (Omosholape et al., 2022).

However, Masime (2016), shows that students in schools with access to laboratory resources perform better academically. On the other hand, research shows that increased enrollment rates in schools lead to resource strain, causing decreased laboratory effectiveness (Akomolafe & Adesua, 2016). These raised questions among stakeholders on how secondary schools cope with increased student' enrollment rates while maintaining high-quality hands-on experiences. Therefore, it is crucial to assess the current status of biology laboratory resources in both private and public secondary schools in Morogoro Municipality.

2. MATERIAL AND METHODS

2.1 Study Area

This study was carried out as a case study in ordinary secondary schools within Morogoro Municipality, Tanzania. Morogoro Municipality was purposively chosen to represent other district in the country. Morogoro Municipality is situated between latitudes 6.6° and 7.0° South and longitudes 37.5° and 37.8° East (Fig. 1). The region has two annual rainfalls and a dry period that separates the long rainy season (March–May) from the short rainy season (October–December). The

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upper elevations of the Uluguru Mountains' eastern slopes receive more than 1,000 mm of rain annually, while the low-altitude plains receive 600 mm (Ojoyi et al., 2015). The municipality encompasses a total of 56 ordinary-level secondary schools, including 29 public schools and 27 private schools. usumawati, 2023).

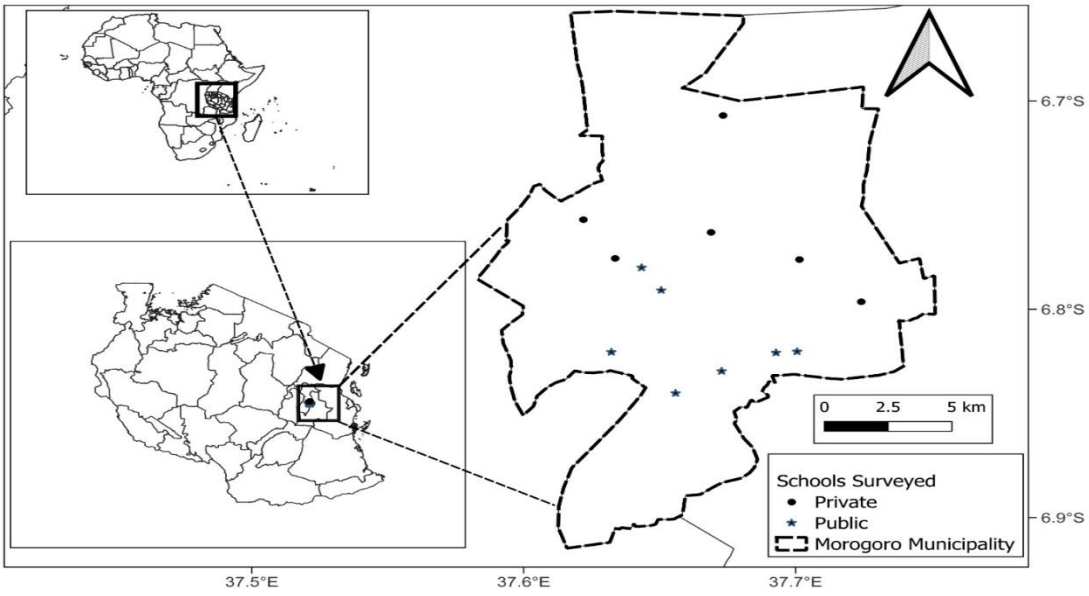

Figure 1: A map showing sampling sites (surveyed schools) in Morogoro Municipality, Tanzania.

2.2 Research Design

The study used a mixed-methods approach. Convergent mixed method design was used in which both quantitative and qualitative data were collected simultaneously during a single data collection phase (Creswell & Creswell, 2018). This design was suitable to this study because provides a comprehensive understanding of the status of biology laboratory resources. A comparative approach was employed to gather data from both private and public schools, allowing for the quantification of differences in laboratory environments between the two school types. Triangulation was used to validate the results from students, Biology teachers, and laboratory technicians, ensuring a comprehensive understanding of the issue.

2.3 Sampling Procedures and Data Collection

This study employed random stratification method to select sampling units from both public and private schools. Stratification was applied to create two groups, one for public schools and one for private schools, after which a simple random sampling technique was used to select schools and students from each group to participate in the study. This sampling method was chosen because every

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item in the population had an equal chance of being included in the sample (Kothari, 2004). A random number generator was used to select 14 schools from a total of 56, including 7 private schools from the 27 available private schools, and 7 public schools from the 29 public schools. The study involved 40 respondents including 13 biology teachers, one laboratory technician and 26 students.

Primary data were collected through questionnaire checklist and structured interview. The questionnaire checklist contained a list of 55 laboratory items listed on the syllabus rated on the scale of sufficient, insufficient, and absent according to the status of those resources in the schools. The structured interviews were conducted from teachers, laboratory technicians and students on the status of laboratories and the challenges faced in doing practical activities. Biology was selected because it is a compulsory subject studied by every student. Form Four students were chosen as they are nearing the end of their curriculum and are likely to have more experience with laboratory environments. Biology teachers and technicians were selected because they are responsible for guiding students in using laboratory resources to develop practical skills.

2.4 Data Analysis

We used a descriptive analysis to assess laboratory human resources between public and private schools. We assessed laboratory physical resources across public and private schools using a Likert scale ranging from sufficient to absent. We compared the differences in percentages between laboratory physical resources using Pearson's Chi-Square test. Content analysis was used to assess teachers and students perceptions of the challenges facing biology laboratories in ordinary secondary schools. All analyses were conducted using R software, version 4.4.1 (R Core Team, 2024).

3.0 RESULTS AND DISCUSSION

3.1 Background information of the participants

This study involves form four biology teachers, laboratory technicians and form four students as shown in Table 1.

Table 1: Information of the school, students, teachers and technicians involved in the study

School Type	Number of schools	Teachers and technician		Students	
	N	Male	Female	Male	Female
Private	6	5	1	5	8
Public	7	4	4	7	6
Total	13	9	5	12	14

Source: Field data 2024

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3.2 Availability of laboratory resources

According to this study laboratory resources assessed were laboratory human resources and laboratory physical resources.

3.2.1 Laboratory Human resources

Human resources were the personnel, such as teachers, laboratory technicians, and students, who are the laboratory users.

Table 2: Biology human resources

Description	School Type	Average
Teachers in-service training programs within a 5 years period	Public	1
	Private	2
Teaching workload	Public	15
	Private	14
Number of Biology teachers	Public	4
	Private	1
Number of students per class	Public	282
	Private	34
Number of laboratory technicians	Public	1
	Private	0

Source: Field data 2024

The study found that biology teachers from public schools attended in-service training with an average of 1 program over the past 5 years, while teachers from private schools attended 2 programs. This indicates almost an equal access to opportunities for professional development across public and private schools. The aim is to equip teachers with the skills needed to adapt to changes in social, economic, environmental, and technological advancements that affect subjects and pedagogical practices (URT, 2020). However, the requirements for in-service training vary from place to place, school to school, and region. The uniqueness of each setting is crucial in education, as there is no one-size-fits-all solution (UNESCO, 2003). Onyango et al., (2022); Wekwe et al., (2024) shows that carrying out continuous training improves teachers' skills and adaptability to modern technologies, benefiting both teachers and students. Limited opportunities for in-service training reflect teachers' weaknesses in adapting to technological advancements and curricula changes, making them unable to deliver high-quality education. Therefore, biology teachers and laboratory technicians from both public and private schools need regular in-service training to upgrade their skills.

Public schools in Tanzania have a higher student-to-class ratio, with an average of 282 students per class, compared to 34 students per class in private schools. This higher ratio affects the teacher-student ratio, classroom management, and availability of laboratory resources, leading to a decrease in

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education quality. This has led to difficulties in facilitating science-related activities in public schools due to large number of students and inadequate supplies and tools (Mokoro, 2020; Pareek, 2019). Active participation in laboratories is possible when the number of students is minimal, allowing interaction with materials, teachers, and themselves. However, when the number is high, not every student can collaborate, forcing teachers to change instruction modes from practical to demonstration. Therefore, public schools need more resources than private schools to meet the needs of each student. Moreover, the study found that 85.7% of public schools had no laboratory technicians compared to 100% of private schools. This is similar to (Pareek, 2019; Wekwe et al., 2024) who found absence of laboratory technician in most of the schools surveyed. This implies that biology teachers struggle to manage laboratory preparation and teaching simultaneously, and due to that, it is expected that students will have a reduced time for hands-on learning, leading to incompetence in the development of practical skills needed to excel in their lives.

3.2.2 Laboratory physical resources

Laboratory physical resources are the materials available in the biology laboratory for facilitating the teaching and learning process. The study found a significant difference in the availability of laboratory resources between public and private schools ($\chi 2$ =67.105, df = 2, p = 0.000) (Fig. 2).

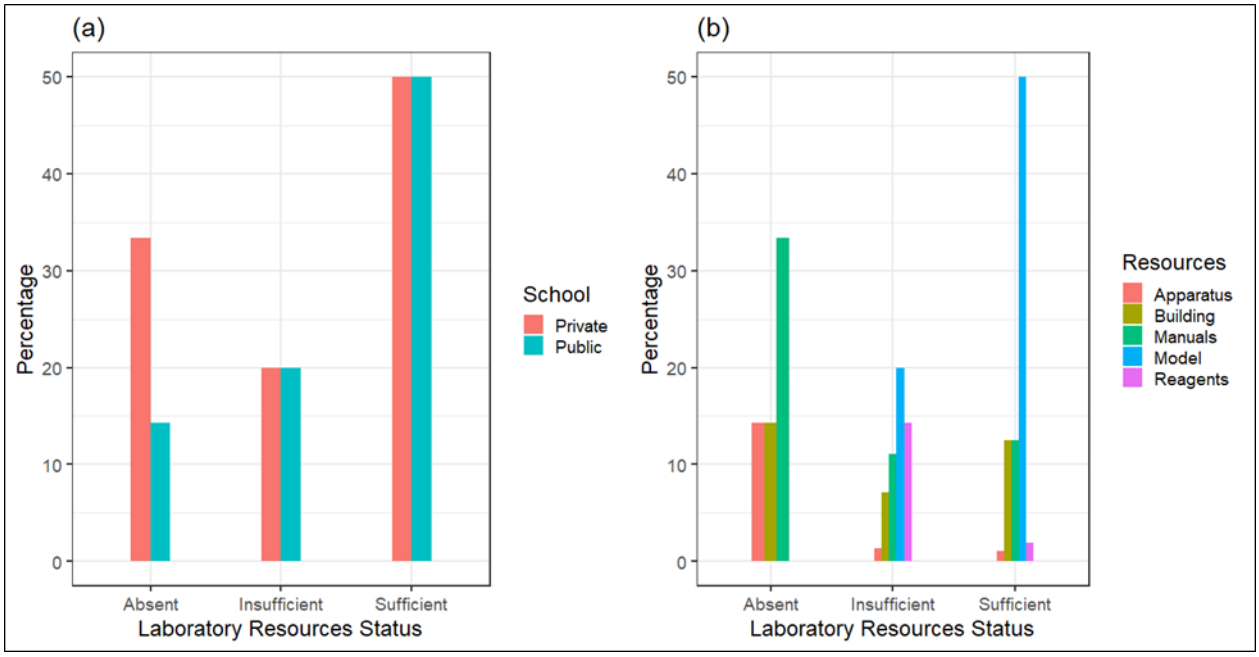

Figure 2: (a) proportion of laboratory resources in public and private schools (b) proportion of five groups of laboratory resources.

The study reveals that 50% of laboratory items were sufficient in both private and public schools, while 33% and 14% were absent in private and public schools, respectively. This indicates a disparity in

resources between public and private schools. The difference may stem from higher demand for resources in public schools, driven by the large number of students enrolled, which significantly impacts students' ability to acquire practical skills, leading to variations in academic performance. The study differs from previous studies in Tanzania, which found that 70% of public schools had sufficient laboratory facilities with basic equipment (Wekwe et al., 2024). The lack of adequate laboratory resources in both schools leads to students not participating in experiments and making effective observations, which can result in teachers and technicians shifting practical work only when students are near examinations (Okafor, 2014; Julius, 2017; Mokoro, 2020). The lack of attention from school principals and lack of finance are major factors contributing to the unavailability of laboratory and associated resources (Daba et al., 2016).

However, models of tissues and organs appeared to have a high percent of presence compared to other resources, likely due to durability and ease of access. This is consistent with Sakibu & Kamugisha (2022) study, which found schools are facing a shortage of physical teaching materials like models, charts, maps, and globes due to insufficient facilities. Models aid students in understanding anatomical structures and functions, highlighting the need for improved laboratory resources to enhance science education quality.

Furthermore, we found that practical manuals, had high percent of absence followed by apparatus and laboratory buildings and their accessories. This is similar with Pareek (2019) who found that nearly 80% of the schools had no specific laboratory manual for conducting experiments. Practical manuals provide a detailed guideline that shows procedures to be followed in conducting experiments; their absence causes students to memorize the procedure instead of understanding the importance of each step. Likewise, Daba et al. (2016); Kaupitwa & Amuthenu (2022) found that lack of laboratory availability, apparatus, and chemicals has the highest rate as a factor that affects laboratory activities in secondary schools. To maximize their impacts, schools, especially biology teachers and laboratory technicians, should find the best way to overcome the burden by improvising the resources using available materials from their environment so as to make sure that students are engaged in real-world scientific exploration.

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Table 3: Students response towards the status of their laboratories

Description	School Type	Proportion (%)				
		SA	A	N	D	SD
We conduct two practical sessions per week	Public	0.0	21.4	21.4	42.9	14.3
	Private	50.0	8.3	16.7	25.0	0.0
We work in groups	Public	64.3	14.3	7.1	14.3	0.0
	Private	66.7	33.3	0.0	0.0	0.0
Teacher uses demonstration method when teaching practical	Public	14.3	35.7	7.1	14.3	28.6
	Private	50.0	16.7	8.3	25.0	0.0

Key: SA = strongly agree, A= Agree, N=Neutral, D= Disagree, SD=strongly disagree.

Table 3 shows that both of the schools conduct practical activities in groups. Working in groups can be advantageous and disadvantageous depending on students' levels of exposure to laboratory teaching. The advantages may stem from enhancing academic achievement, fostering effective communication abilities, and strengthening self-assurance (Kumi-manu et al., 2024). Daba et al. (2016); Tordzro & Ofori (2018) found that the hands-on activities offered in the laboratory has the potential to stimulate students interests in the subject, teach laboratory techniques, enhance knowledge retention, and shed light on how scientific attitudes and abilities are developed. On the other hand, its disadvantage is that clever students may dominate the group and do all the tasks given while the lazier may participate little or not at all. Therefore, individual practical work is crucial for developing valuable laboratory skills, as students directly engage with scientific phenomena, materials, and equipment.

Furthermore, 50% of public-school teachers use the demonstration method when teaching compared to 66.7% of private schools. This method, however, has been found to limit students' opportunities to develop practical skills and promote passive learning, hindering critical thinking and problem-solving abilities. This approach promotes passive learning, where students act as observers without active engagement, hindering the development of critical thinking and problem-solving abilities. Research shows that a demonstration approach is conducted in schools with insufficient laboratory resources, where teachers demonstrate on the table and then students follow the demonstration, which deprives learners' science process skills (Kibirige & Maponya, 2021). (Pareek, 2019) observed that whenever demonstrations were held, 65% of the students could not see clearly what the teacher was demonstrating and 73% of the students were of the opinion that teachers did not involve students in the demonstration. This approach promotes passive learning, where students act as observers without active engagement, hindering the development of critical thinking and problem-solving abilities. This

suggests that a blended approach in laboratory teaching is needed to ensure that each student achieves the intended learning outcomes.

3.3 Challenges encountered in the laboratory due to increased student enrollment

The challenges identified in conducting laboratory practical after an increased student enrollment were shown in Table 5.

Table 5: Students' response on the challenges they are facing in conducting practical

Challenges Faced	School Type	Proportion (%)				
		SA	A	N	D	SD
Inadequate time	Public	45.5	36.4	4.5	9.1	4.5
	Private	16.7	33.3	0.0	38.9	11.1
Large class size	Public	50.0	45.5	4.5	0.0	0.0
	Private	11.1	16.7	0.0	44.4	27.8
Lack of enough laboratory resources	Public	36.4	13.6	9.1	4.5	36.4
	Private	16.7	11.1	22.2	16.7	33.3
Lack of students motivation	Public	22.7	27.3	9.1	18.2	22.7
	Private	5.6	11.1	5.6	44.4	33.3

Key: SA = strongly agree, A= Agree, N=Neutral, D= Disagree, SD=strongly disagree.

Table 5 revealed that 81.9% of public schools and 50% of private schools faced inadequate time for practical work in conducting practical. This is similar to Imanda (2020), who found time limitations, and the mode of testing in examinations with less emphasis on practical activities as among challenges faced in the implementation of practical work in Kenya. Time limitation deter students' opportunity to fully engage in practical activities, leading to poor development of laboratory practical skills and decrease the efficiency of hand on experience. As a result, teachers will prioritize theoretical practical lessons over practical lessons, and when the practical lesson is conducted, the teachers will have little time to observe students work and provide constructive feedback.

Furthermore, the study found that 95.5% of public schools had larger class size compared to 27.8% of private schools. This means that laboratory rooms are small such that there is an absence of enough space to work on it. This is similar to Mokoro (2020), observation that laboratory space was insufficient to accommodate all students in a class for experimental activities, limiting the number of students able to conduct experiments at once. To address this, teachers may have to form larger groups, which can increase the risk of accidents and damage to resources. Improper handling and use of laboratory resources can lead to resource wastage, and reduced effectiveness in biology practical (Kibani, 2021).

The study revealed that 50% of public schools lacks enough laboratory resources to 27.8% of the private schools. This is in contrast with Wekwe et al. (2024) who found that about 70% of the public schools surveyed then had sufficient laboratory facilities with all necessary basic laboratory equipment. The differences may be due to a high demand for resources in public compared to private schools caused by the large number of students enrolled in public schools. Lack of sufficient laboratory resources affects effective laboratory teaching and learning, leading to the inadequate practical sessions. Dagnew et al., (2019) noted that incorporating practical work into science education improves students' attitudes and performance in biology. As highlighted by Daba et al. (2016) and Kaupitwa & Amuthenu (2022), the lack of laboratory facilities, apparatus, and chemicals is the primary factor hindering laboratory activities in secondary schools. This shortage restricts students' ability to grasp scientific concepts and learn proper procedures, ultimately preventing the achievement of curriculum objectives.

Public schools show that 50% of the students are not motivated to conduct practical activities compared to 16.7% of private schools. The findings are in contrast with (Daba et al., 2016) who found that 75% of the students were are interested towards practical activities. Imanda (2020), noted that motivated learners enjoy the learning process, which helps them benefit more and understand investigative methods. Students find themselves uninterested in engaging in practical activities when there is limited access to the laboratory resources. This study found that students work in a group of an average of 7 students. This made some students unable to feel the real meaning of learning by doing because it is likely that some students dominate the groups, and others find themselves less engaged in hands-on learning. These deter the development of necessary attitudes towards science subjects and practical skills needed in their careers and life in general.

Another challenge identified by the teachers reported that they are provided with low-quality laboratory facilities, such as industrial chemicals instead of proper laboratory-grade chemicals. This was cited by one of the teachers from a public school:

"Most of the heads of schools are the ones who purchase resources; as a result, you may find that some chemicals are not good. For example, a supplier can bring you industrial chemicals instead of laboratory chemicals or apparatus that you did not order or you do not need them."

This undermines teaching morale as the teachers will use a lot of time to fix the error that might be brought by using the wrong chemicals or equipment.

A private school biology teacher reported that:

"School administrators are not willing to purchase teaching resources once they are required; rather, they wait until the checklist is provided for regional and national examinations."

Administrators are hesitant to make purchases beforehand, fearing they will invest in materials that will remain unused. The situation demoralizes teachers, leading to students lacking hands-on learning, which can negatively impact future careers and their understanding of concepts, as they may memorize answers without fully comprehending them.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

This study has provided insights into the status of biology laboratories. The study revealed a large number of students in public schools compared to private schools. This indicated a statistically significant difference in the availability of laboratory resources between schools. However, 50% of both schools had sufficient laboratory items as listed on the syllabus, while private schools showed a deficit of resources compared to public schools. On the other hand, both schools show the inadequacy of laboratory technicians. The study also identified insufficient time for conducting practical as the key challenge faced by both teachers and students in private and public schools. Other challenges identified in public schools include large class size and lack of laboratory resources.

4.2 Recommendations

Based on the findings of this study, it is recommended that the government through Ministry of Education Science and Technology to allocate a realistic budget to address the need of each individual students and provide regular in-service training and seminars to help teachers adapt to curriculum changes. The government, through its bodies, should distribute laboratory resources to schools to reduce the possibility of purchasing items that are not in line with school requirements. Also, the school quality assurance team should ensure timely purchase of laboratory resources when needed to minimize the burden of purchasing close to examinations. Furthermore, the government should recruit laboratory technicians to assist teachers in preparing and conducting practical, enhancing the effectiveness of practical learning.

5.0 Acknowledgement

We would like to express our gratitude to the Sokoine University of Agriculture (SUA), especially the Department of Biosciences, Department of Educational Psychology and Counselling, and the Department of Educational Curriculum and Instruction, for reviewing and approving the research proposal. We also appreciate the Regional and Local Government Authorities (RLGA) for granting the necessary permits. Our sincere thanks go to all the school staff and students whose contributions facilitated the timely completion of data collection in the field.

6.0 Funding statement

This study is a self-funded project.

7.0 Ethical statement

This study was conducted under the 2022 research and ethical guidance from the Sokoine University of Agriculture (SUA, 2022).

8.0 Limitations

The study was planned to involve 14 schools, including 7 public and 7 private schools, but due to logical issues, the researcher failed to reach all schools. Therefore, the strata in this study consisted of 6 private schools and 7 public schools.

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