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Managing Practical Work in Secondary Schools' Science Education: An Assessment of Teachers' Practices

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Abstract

This paper examined how science teachers manage practical work in middle secondary schools in Tanzania and how they design, prepare, implement, assess, and evaluate laboratory work. A descriptive survey design with classroom-structured observations was used. Questionnaires and observation checklists were used to gather data on 64 science teachers, and SPSS was used to analyse the data using descriptive statistics. The results showed that the strongest element was the implementation of practical work: 100% of the observed teachers could explain the steps of a procedure step-by-step, and 83.3% could relate the practical activities to the theoretical ones. Conversely, 33.3% of teachers consistently provided safety instructions and encouraged inquiry-based learning, and 41.7% used formative assessment strategies during practical sessions. In general, there were higher scores on practical implementation (75%) than on practical assessment (65.5%), indicating an imbalance in the administration of laboratory learning. The research also found that although teachers had high procedural competence, the safety practices, inquiry facilitation, and formative assessment were weak, restricting the efficacy of practical work. The results indicate the need for specific professional training, better laboratory staffing, and administrative support to facilitate safe, inquiry-based, and assessment-driven practical science teaching in public Tanzanian secondary schools.

Keywords: Inquiry-based Learning, Laboratory Safety, Practical Work, Science Education, Science Practices.

Introduction

Global Perspectives on Practical Work in Science Education

The extensive use of practical work is commonly acknowledged as one of the key elements of successful science education in most parts of the world. It will allow learners to interact directly with scientific phenomena, thereby advancing conceptual, investigative, and scientific reasoning. Using practical exercises, students can observe, measure, experiment, and apply abstract scientific knowledge in practical settings (Oliveira & Bonito, 2023). When properly planned, organised, and guided by teachers, practical work is also a crucial means of developing inquiry, critical thinking, and problem-solving skills (Chen, 2024; Afyusisye & Gakuba, 2022).

Although it is a powerful pedagogical method, its inclusion in the curriculum does not ensure its effectiveness in practical work. Research in other educational settings reveals

that the effectiveness of practical activities largely depends on teachers' ability to regulate laboratory and outdoor activities, particularly in their preparation, organisation, classroom control, assessment, and safety (Apeadido et al., 2024). Therefore, there has been a growing focus on quality rather than on the availability of practical activities.

Practical Work in Tanzanian Science Education

In Tanzania, science practical work is a compulsory subject in the secondary school curriculum in Physics, Chemistry, and Biology. The documents on the national education policy emphasise the importance of laboratory investigations as the primary means by which students are supposed to learn science, gain practical skills, and develop positive attitudes towards science (Kinyota, 2020). The curriculum also promotes students' experimentation that fosters meaningful learning and better performance in science subjects.

As part of the Secondary Education Development Plan (SEDP), Tanzania has invested heavily in establishing laboratory facilities in secondary schools, which is part of its policy to ensure sufficient access to science laboratories across the country. However, severe inequalities in resource access persist, especially in rural areas. Although laboratory infrastructure is irreplaceable, empirical evidence indicates that quality empirical instruction occurs through teachers' pedagogical activities (Acharya & Subedi, 2023). Studies have also reported that a significant number of teachers place importance on completing the mandated practical exercises as per examination requirements, suggesting a limited scope of being able to get involved and develop higher-order thinking skills in the long term (Kinyota, 2020).

Nevertheless, an empirical study of Tanzanian secondary schools demonstrates that there are severe problems with the implementation of practical science teaching, which are lack of laboratory infrastructure, equipment, materials, insufficient laboratory time, and large classes (Mokoro, 2020). Consequently, most science teachers are accustomed to applying teacher-centred methods through instruction, including demonstrations and theoretical explanations, and do not involve students in practical experiments (Ajani, 2023). Despite high-level policy promoting practical science instruction, the extent to which classroom practices reflect these goals remains debatable.

Gaps in Existing Literature

The literature review of previous research in Tanzania has focused chiefly on identifying general concerns related to science education, including curriculum implementation, teacher qualifications, and student performance. Although these studies are illuminating, the empirical research on practical work management practices by science teachers in the context of available resource constraints is relatively scarce. There is restricted information on how teachers plan, design, implement, assess, and evaluate practical activities, as well as on how these management practices relate to the available facilities to support laboratories' impact on practical science teaching quality.

Although the application of laboratories is recognised as the key to successful practical work (Catherine, 2022), there is a lack of context-based information on how the number of laboratories, spatial planning, material accessibility, and safety statements influence the organisation and efficacy of practical work in the Tanzanian secondary schools. Those gaps underscore the need for empirical research that goes beyond policy idealism to examine real-life classroom practices and contextual realities.

Purpose of the Study

This study aims to examine the effectiveness of the practical work management practices of science teachers in public secondary schools in Tanzania. In

particular, the research focused on two significant issues. First, it evaluated the sufficiency and accessibility of science laboratory facilities in terms of the number of laboratories, laboratory spatial distribution, and the number that could accommodate actual science work. Second, it examined the effectiveness of practical work management practices among science teachers, particularly in the preparation and design of science practical work, its implementation and assessment, and compliance with safety procedures.

The research, by addressing these questions, aims to offer empirical evidence on the relationship between laboratory infrastructure and teacher management practices in the delivery of practical science education. It is expected that the findings will guide curriculum developers, institutions of teacher education, administrators of learning institutions, and policymakers to enhance the quality and consistency of practical science teaching in Tanzanian state secondary schools.

Theoretical Framework

Constructivist and experiential approaches of learning were the basis of this study, focusing on the active engagement of the learner and the creation of knowledge through first-hand experience. The concept of learning in science education has been interpreted as involving students in practical tasks, such as experimentation, reflection, and the application of the idea in real situations. Laboratories in schools offered opportunities for such learning, provided there was sufficient infrastructure, equipment, and materials to support teaching and assessment (Allen, 2022). In the absence of laboratory facilities or resources, the experiential learning cycle could be disrupted, leading to fewer opportunities for students to actively participate in scientific processes and gain more effective practical learning (Nwuke, 2024).

Constructively, the teacher is vital in guiding learners in the field of practical work by providing support within the Zone of Proximal Development—a set of tasks that can be handled by learners with the assistance of instructors (Efgivia et al., 2021). This assistance may be observed in real lessons in planning and showing the processes, overseeing experiments, and helping reflect on and discuss the outcomes. Well-managed laboratories are beneficial for teachers in structuring these stages to facilitate inquiry, collaboration, and theory-practice connections (Jegstad, 2023). Building on the principles of constructivist and experiential learning, the most effective practical work management practices should be based on the plan, preparation, implementation, assessment, and evaluation of activities (Chen, 2024; Chuene and Teane, 2024; El Masri et al., 2023). These parts of this study informed the research design, the development of an instrument, and the discussion of the research findings in Tanzanian public secondary schools.

Linkage between Theoretical Framework, Constructs, and Measured Variables

The theoretical framework was used to identify key constructs based on constructivist and experiential learning theories, and to operationalise them into measurable variables. This agreement matched the theory, the research design, and the data collection tools, as abstract theoretical principles were correlated with observable, measurable characteristics of practical science teaching and learning. Table 1 provides an overview of the connections between the underlying theories, core constructs, their operational definitions, and application indicators in questionnaires and observation checklists.

Table 1. Relationship between Theory, Constructs, Operational Definitions, and Measured Variables.

Theory	Construct	Operational Definition	Measured Variables
Constructivist Learning Theory	Teacher Scaffolding	Structured guidance provided by teachers to support learners' progression within the Zone of Proximal Development during practical work.	Clarity of instructions; demonstration of procedures; supervision during experiments; feedback and guidance
	Inquiry-Based Learning	The extent to which practical activities promote learners' questions, explorations, collaborations, and active participation.	Student participation; group work; opportunities for questioning; learner autonomy
Experiential Learning Theory	Practical Work Planning	Advance organisation of practical activities aligned with curriculum objectives and available resources.	Practical objectives in lesson plans, syllabus alignment, and time allocation
	Practical Work Preparation	Teacher readiness through the organisation of materials, equipment testing, and laboratory setup.	Availability of materials; functionality of equipment; laboratory readiness
	Practical Work Implementation	Facilitation of hands-on activities enabling concrete experience and active experimentation.	Learner-centred approaches; supervision; student engagement
	Assessment and Evaluation	Use of formative and summative strategies to assess understanding and skills gained through practical work.	Practical reports; oral questioning; feedback on performance

	Safety Management	Enforcement of laboratory safety procedures during practical activities.	Adherence to safety rules, availability of safety equipment, and teacher supervision
Contextual Enabling Factors	Laboratory Infrastructure	Availability and adequacy of physical facilities and resources supporting practical work.	Number of laboratories, spatial layout, availability, and condition of equipment

Methodology

Research Design

This study employed a descriptive survey design to assess the effectiveness of science teachers' practical work management practices in public secondary schools. The quantitative component consisted of a structured questionnaire administered to 64 science teachers, while the qualitative component involved structured laboratory observations and practical science lessons. Quantitative and qualitative data were collected concurrently, analysed separately, and then the results were combined for a comprehensive understanding. This method was adopted as it supported the study's validity by using various data collection methods and helped to connect statistical findings with real-world education (Ming, 2023; Adhikari & Timsina, 2024).

Participants of the Study

This study involved a total of 64 science teachers selected from public secondary schools in the Nyamagana and Magu districts in the Mwanza region. The targeted participants were diverse in terms of size and geography, providing different groups of respondents to the survey. Schools were sampled using a stratified random sampling method, where both urban and rural settings were included in the study. In the sampled schools, science teachers were recruited through purposive sampling because they often have special skills and are directly involved in laboratory instruction, which is crucial to the research objectives of this study. In the case of the student population, simple random sampling was utilised to remove selection bias, as well as to encourage the representativeness and fairness of the sample.

Instrumentation and Data Collection Procedures

Teacher Questionnaire

A structured questionnaire was developed using the constructivist and experiential learning theories and administered to gather data on teachers' practical work management practices. The questionnaire was designed to comprise five domains: plan, preparation, implementation, assessment, and evaluation of practical work. Responses were measured on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree to indicate teachers' self-reported practice in the domains.

To establish instrument validity, the questionnaire was also reviewed by experts in science education who assessed its relevance, clarity, and correspondence with the study's goals. A pilot study was done with the science teachers in the non-primary schools, which were public secondary schools. The pilot study provided feedback that was necessary to revise ambiguous items and wording. The questionnaire's reliability was assessed using Cronbach's alpha, which yielded satisfactory levels of reliability (α =

0.70) across all domains, indicating the instrument was reliable for data collection.

Observation Checklist

Data on the actual implementation of the practical work during laboratory sessions were collected using a structured observation checklist. The checklist included observable points on lesson preparation, clarity of instructions during teaching, learner attention, inquiry-based activities, assessment practices, and safety management. The constructs measured by the questionnaire were matched to the checklist to enable a direct comparison of self-reported with observed practices.

Inter-rater reliability was also determined to increase the reliability of the observation data. Two trained observers observed selected practical lessons and recorded the observations using the checklist. The percentage of agreement and Cohen's kappa coefficient (0.84) indicated a satisfactory level of consistency. Discrepancies were discussed and resolved through consensus to improve the accuracy of the observations, indicating a satisfactory level of agreement.

Data collection was performed in three distinct steps. First, all science teachers in the sampled public secondary schools completed the questionnaire. Second, direct classroom observations of practical science lessons were conducted using an observation checklist. These observations offered the possibility of systematically recording teachers' teaching behaviours and provided the scope to make them comparable to self-reported data (Kholifah & Sofwan, 2024). This step provided the necessary background to explain how physical resources could impact the implementation of practical work in science teaching.

Data Analysis

The survey questionnaire and observation checklist provided a detailed dataset that was subjected to statistical analysis. The percentages, frequencies, and mean scores were obtained to measure prevalence. Meanwhile, the effect of different practical work management practices was subjectively rated. Self-reported data were compared with the corresponding observer-based data to determine the alignment or discrepancy between the reported and actual instructional practices in the classroom setting.

Research Ethics

The UNICAF University Research Ethics Committee and the Tanzania Commission for Science and Technology (COSTECH) provided ethical approval for this study. Every respondent participating in this study was informed about the purpose of the study and provided written consent. Anonymity and confidentiality were maintained throughout the study period. All data collected was kept safe and used only for educational purposes.

Results

Availability of Science Laboratories

Adequate provision of practical science instruction in secondary schools is impossible without science laboratories. Teachers were asked whether their schools had functional science laboratories. The responses are summarised in Table 2.

Table 2. Reported Availability of Science Laboratories by Teachers.

Respondent group	Laboratory availability	Frequency (n)	Percentage (%)
Teachers	Yes	64	100.00
	No	00	00.00

The findings in Table 2 indicated that science laboratories were widely available in the participating public secondary schools, with 100% of the teachers confirming their presence.

Science Laboratory Infrastructure and Resource Sufficiency

Teachers also prepared reports on the number of laboratories, laboratory organisation, and the sufficiency of resources. Table 3 and Figure 1 provided the results.

Table 3. Teachers' Responses on Science Laboratory Structure and Resource Adequacy.

Aspect	Category	Frequency (n)	Percentage (%)
Number of Laboratories	One	23	35.90
	Two	08	12.50
	Three	33	51.60
	More than three	00	00.00
Total		**64**	**100**
Laboratory Organisation	One lab for each science subject	33	51.60
	One shared lab for all science subjects	31	48.40
Total		**64**	**100**
Laboratory Resource Sufficiency	Resources are adequate	35	54.70
	Resources are inadequate	29	45.30
Total		**64**	**100**

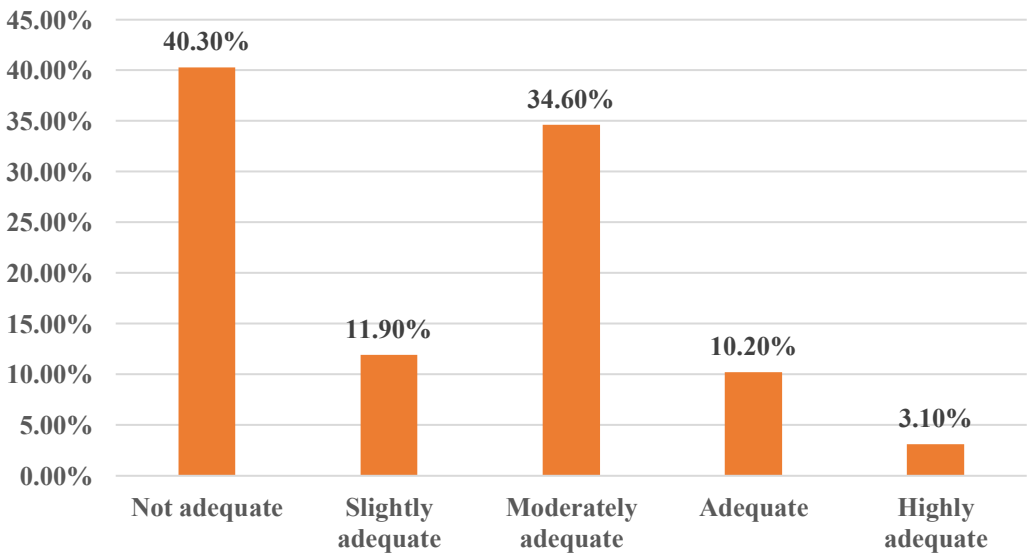

Figure 1. Teachers' Responses to the Adequacy of Laboratory Resources.

The findings revealed differences in the laboratory infrastructure across schools. A slight majority of the teachers (51.60) stated that they had individual labs for each science, whereas 48.40 percent used shared labs. Resource-wise, 54.70% of teachers reported adequate laboratory resources, while 45.30% said otherwise.

Effectiveness of Science Teachers' Practical Work Management Practices

Teachers indicated their participation in five elements of practical work management practices: design, preparation, implementation, assessment, and evaluation. These components had mean ratings given in Figure 2.

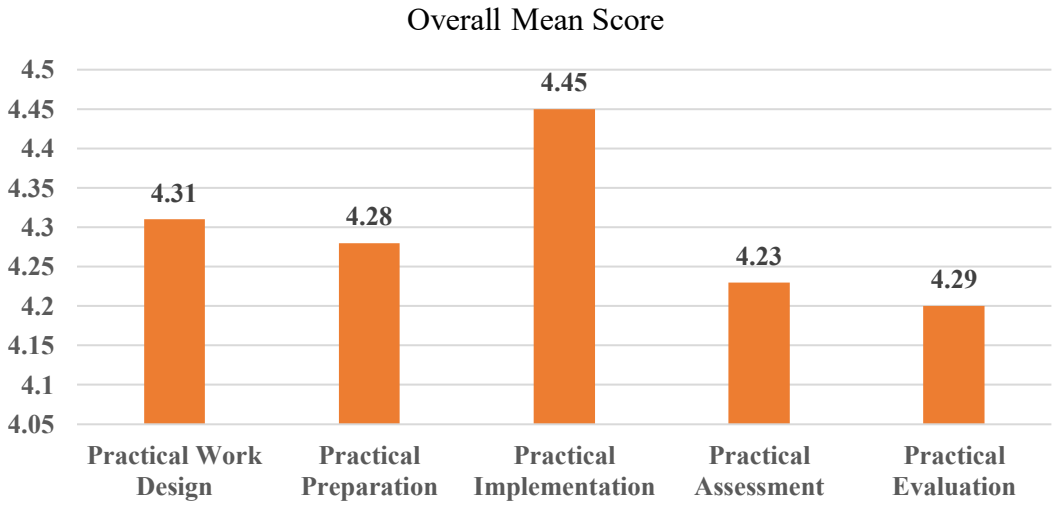

Figure 2. Teachers' Mean Ratings across Five Practical Work Management Practices.

The results in Figure 2 indicated that among the dimensions of science practical work management practices, implementation received the highest mean score (M = 4.45), followed by design (M = 4.31), evaluation (M = 4.29), preparation (M = 4.28), and assessment (M = 4.23).

Observed Laboratory Practices

A structured checklist was utilised to conduct classroom observations to assess teachers' self-reported practices. Table 4 summarises the observed practices.

Table 4. Observed Teachers' Practical Work Management Practices (n =12).

Criteria	Frequency (n)		Percentage (%)	
Practical Implementation	**Yes**	**No**	**Yes**	**No**
The teacher provides step-by-step explanations of experimental procedures.	12	0	100	0
Teacher links practical work to theoretical lessons	10	2	83.30	16.70
The teacher conducts a trial of practicals before students perform them.	10	2	83.30	16.70
Clear safety instructions are given before starting experiments	4	8	33.30	66.70

Overall percentage			**75.00**	**25.00**
Practical Assessment	**Yes**	**No**	**Yes**	**No**
The teacher observes students during experiments to assess their understanding of the material.	9	3	75	25
The teacher monitors students during experiments to ensure adherence to safety measures	10	2	83.30	16.70
The teacher supervises students throughout the practical session	9	3	75	25
The teacher encourages inquiry-based learning during practicals (e.g., asking questions, concluding)	4	8	33.30	66.70
Formative assessments (e.g., observations, questioning) are used during practicals	5	7	41.70	58.30
Students are encouraged to take responsibility for their learning during practical activities	9	3	75	25
Students are asked to write laboratory reports after practical activities.	9	3	75	25
Overall percentage			**65.50**	**34.50**

Source: Sanjito, 2025, field data

The use of a structured checklist in classroom observations ensured that teachers had practice in managing their work. The teachers explained the experimental procedures in steps (100%), but 83.30% integrated practical activities with theoretical lessons and conducted practice runs before the students. Only 33.30% of people provided clear safety instructions, 75% focused on students' knowledge and the sessions they were going through, and 83.30% monitored safety during the assessment. However, 33.30% promoted inquiry-based learning, and 41.70% employed formative evaluation. In 75% of the sessions, student autonomy was noted in the writing of the laboratory report. In general, the practical implementation was 75%, and the assessment was 65.50%. These findings suggested that teachers consistently offered procedural guidance and supervision of practical activities, whereas assessment practices, inquiry facilitation, and safety instructions were less uniform in observed lessons.

Discussion

Availability of Science Laboratories

The availability of universal science laboratories in sampled public secondary schools indicates significant progress in enforcing national policies that place greater emphasis on practical science learning in Tanzania. This observation is consistent with findings from other sub-Saharan African settings, where education reforms have increased access to laboratory services (AbiDoye et al., 2022). Nevertheless, the availability of a laboratory does not guarantee a successful practical teaching

period, as the results of the current study later show the inadequacy of equipment and organisation in the laboratories. In terms of experiential learning, competent hands-on learning requires access to laboratories and well-equipped functional environments to facilitate experimentation and inquiry. This finding indicates that the policy's intervention should go beyond infrastructure delivery to include sustained provision of laboratory facilities and maintenance, with a view to improving the quality and effectiveness of practical sciences instruction.

Science Laboratory Infrastructure and Resource Sufficiency

The results of the science laboratory infrastructure and resource adequacy indicate significant variation among schools and essential implications for the management and quality of instruction in practical sciences. Though only a slight majority (51.60) of the teachers reported having independent laboratories for each science subject, a large percentage (48.40) utilised shared laboratories, which could limit opportunities for subject-specific practical work and flexibility in scheduling. Although teachers had a relatively small majority (54.70) in their assessment of whether the available lab resources were adequate, the comparatively high number of teachers who reported inadequacy (45.30) indicates critical discrepancies in the allocation of equipment and consumables. This contradictory image helps clarify the disparities observed between teachers' self-reported practices and their classroom observations reported in other parts of the research. Teachers in better-equipped or subject-specific laboratories would also be more likely to report sufficient provision and effective practical management.

In contrast, teachers in shared or under-equipped laboratories may over-report positive practices to meet curricular requirements, despite practical constraints. The problem of resource scarcity, in particular, directly influences teacher behaviour, commonly leading to increased use of demonstrations, lower rates of student-led experimentation, and less frequent use of inquiry learning, especially when consumables and safety gear are insufficient. This is one of the reasons some practices, such as the procedure explanation, are rated highly. Meanwhile, more resource-intensive practices, such as inquiry-based engagement or safe, hands-on experimentation, are not always applied. Altogether, the findings indicated that the state of infrastructure was not enough. Long-term investment in the laboratory facilities, fair distribution, and teacher assistance was required to convert policy intentions into effective and learner-centred practical science learning as sustainable as the theories of experiential and constructivist learning (AbiDoye et al., 2022; Mokoro, 2020; Efgivia et al., 2021).

Effectiveness of Science Teachers' Practical Work Management Practices

The results revealed that science teachers in the sampled public secondary schools were highly competent in their applications of practical work, as the mean scores in the five management dimensions (plan, preparation, implementation, assessment, and evaluation) were high. The highest scores were consistently obtained in implementation, indicating that teachers were confident in their abilities to conduct experiments, oversee students, and discuss procedures during practical lessons. This trend was consistent with the existing literature, which highlighted that educators were more focused on the performance aspect of practising tasks, as it was most strongly correlated with syllabus coverage, examination requirements, and pre-service training expectations (El Masri et al., 2023; Manyilizu, 2023). Conversely, the relatively lower scores in preparation and assessment indicated that less attention was paid to activities such as advanced planning, risk anticipation, formative assessment, and post-

practical reflection, even though they were all important for meaningful learning.

This difference between the generally favourable self-reports of the teachers and the relatively lower observational ratings can be partially attributed to contextual limitations in schools. Self-reported data can be based on what teachers want to or should do, but observations are based on what is practically implemented within an existing state of affairs. Those practices that were rated consistently high, including explaining procedures step-by-step and making connections between experiments and theory, mainly rely on teachers' pedagogical knowledge rather than on material resources. These are well instilled in teacher training courses and curriculum manuals, and this is one of the reasons why they perform uniformly. Conversely, the practices with low scores, such as explicit safety instruction, inquiry-based facilitation, formative assessment, and laboratory reporting, tend to include sufficient equipment, safety gear, adequate time, and manageable class sizes. In situations where laboratories are shared, equipment is limited, or consumables are scarce, teachers can limit student autonomy, cut down on inquiry activities, or favour getting experiments done rather than more thorough assessment and reflection.

The lack of resources thus influences teachers' behaviour in significant ways. In poorly equipped laboratories, educators might minimise practical work to reduce safety issues, thereby limiting the potential for questioning, research, and formative evaluation. On the same note, the reduced focus on inquiry-based tasks and laboratory reports can also indicate time pressure and workload, especially in institutions with less access to laboratories. On the one hand, the overall practical implementation scored relatively high. On the other hand, the low score in assessment and inquiry reveals a tendency to prioritise completing procedures over developing scientific reasoning, reflection, and communication skills. These results indicated that pedagogical training was insufficient to enhance the management of practical work. Specialised professional learning should be supported by improved facilities in terms of laboratories and institutional facilities, realistic safety, and assessment to ensure that teachers can transform high-level procedural competence into inquiry-based, reflective, and safe learning of practical science as part of constructivist and experiential learning principles (Chen, 2024; El Masri et al., 2023).

Results and Discussion

This study analysed the practical work management practices among science teachers in public secondary schools in Tanzania across the design, preparation, implementation, assessment, and evaluation stages. In general, the results indicated that the teachers exhibited high levels of procedural competence, especially in the application of practical lessons, student monitoring, and connecting experiments to theoretical material. However, classroom observations indicated that certain practices were not consistently applied, such as explicit safety instruction, inquiry-based scaffolding, formative assessment, and systematic laboratory reporting. These lapses indicated that teachers were occupied with the practical lessons underway, while cognitive involvement and official safety and evaluation procedures had not yet been deeply integrated into everyday practice. Moreover, differences in schools' laboratory facilities (including the number of subject-specific laboratories) limited uniformity and the quality of practical work.

The research is unique in its approach to the study, as it triangulated teachers' self-reported data with classroom observations, thereby exposing differences between reported practices and classroom implementation. This body of mixed evidence shows the influence of structural factors, such as resource availability and the organisation of the laboratory, on the teacher's behaviour during a practical lesson. Based on these results, the research suggests

specialised professional training that would include inquiry-based teaching, formative evaluation, laboratory safety, and scientific reporting, as well as policy-level work to mitigate inequity in infrastructure and harmonise the principles for managing practical work. Further studies should examine how increased capacity and laboratory resources for teachers can lead to quantifiable benefits in student engagement and the development of scientific skills.

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