



The Impact of Science Practical Work Management Practices on Student Learning Outcomes

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Abstract

Objectives. This study examined the impact of science practical work management practices on student learning outcomes in public secondary schools in Tanzania. Specifically, it aimed to determine the role of teachers in organizing and managing laboratory activities with respect to students' academic performance and interest in science subjects.

Materials and Methods. A convergent parallel mixed-methods design was employed, integrating quantitative and qualitative data collected concurrently from 64 science teachers and 295 students across 22 public secondary schools in the Nyamagana and Magu districts. Data were gathered using questionnaires and structured classroom observations. Quantitative data were analyzed using descriptive statistics, Pearson's correlation, and linear regression in SPSS (version 25), while qualitative data were examined through thematic analysis to complement and contextualize the statistical findings.

Results. The findings revealed a strong positive correlation between science practical work management practices and student learning outcomes ($r = 0.734, p < 0.01$). Regression analysis further indicated that students' academic performance was strongly predicted by teachers' management practices ($\beta = 0.834, p < 0.01$). These quantitative results were supported by qualitative evidence showing that effective teacher preparation, efficient organization of resources, and active student engagement enhanced learners' confidence and conceptual understanding. Nevertheless, inadequate facilities and large class sizes were identified as major constraints.

Conclusions. The study concludes that well-managed science practical work substantially improves student learning outcomes by fostering engagement, motivation, and conceptual mastery. To enhance the quality of science education, particularly in resource-constrained schools, strengthening teachers' competencies in planning and conducting laboratory activities is essential.

Keywords: science practical work, laboratory management, learning outcomes, teacher practices, Tanzanian secondary schools.

Introduction

It has been established that science education is one of the most important pillars of national development to the countries who intend to achieve technological advancement, industrialization, and socio-economic development (Tibye-habwa et al., 2017). It also imparts scientific knowledge, problem solving skills, and practical skills to students in order to address the demands of the arising global challenges and to support the development.

Other subjects such as science that include biology, chemistry, and physics are also given importance in the secondary school curriculum in Tanzania due to the significant influence they have in equipping students to work in fields

like medicine, engineering, agriculture, and environmental management (Kamal Prasad Koirala & Koirala 2019). The Tanzanian government has made countless national policies and curriculum changes to emphasize the role of science education in making students more scientifically literate and encouraging more students to study science-related subjects.

Despite these, however, student achievement in science subjects in the Tanzanian secondary schools is still below average. The results of the national examination always show low success rates, insufficient conceptual knowledge, and preparation to attend tertiary-level science programmes (Kinyota, 2020). The inability to connect theory to practical life is one of the problems that many students experience and jeopardizes the process of critical thinking and innovation. Scholars and policymakers have blamed such consistent underachievement on a few factors, such as teacher-centered

pedagogy, shortage of instructional materials, overcrowded classes, and, most importantly, poor management of practical work in science.

Practical work management is one of the main issues in the efficient teaching of science because it helps bridge the gap between theory and practical experimentation. The aim of practical work is to assist students in gaining inquiry, problem-solving, and scientific investigation confidence (Oliveira and Bonito, 2023). This makes science not only an abstract topic but also an active and interesting learning process. Laboratory work when done properly encourages students to observe, experiment, analyse and make conclusions and this is the essence of scientific literacy. Working with bad management, on the other hand, does not give the desired practical work. educational effect and results in passive learning and memorization of ideas without the actual comprehension of the material.

Empirical evidence around the world supports the concept that well-structured and properly managed laboratory sessions can help students achieve better results and become more motivated and interested in science (Catherine, 2022). The experience of developed nations has shown that well-organized practical classes, sufficient facilities, and teachers' instructions contribute to more profound knowledge and better memorization of scientific information. However, in most sub-Saharan African nations, such as Tanzania, there is a significant impediment to the application of practical work. Such difficulties include the absence of laboratory equipment and materials, poor financial support, and teacher training in laboratory management (Jegstad, 2023). This implies that most schools in Tanzania are restricting practical lessons to teacher demonstrations or worksheet-based simulations, as opposed to authentic practical experiences. This scenario limits students' access to the direct management of science phenomena, hence compromising the goals of inquiry learning.

Despite the literature on the topic of teaching science and instruction in schools in Tanzania, most studies have not targeted the development of an analysis of how the management of practical work affects the learning outcomes of students in schools. Most of the research that has been conducted has inclined towards covering general pedagogical issues; therefore, there is a gap in knowledge on how effective management practices, such as planning, preparation, implementation, equitable participation of students, supervision, assessment and evaluation, can be used to enhance student performance in science. This disconnect is important because good management can guarantee the safety and efficiency of laboratory sessions as well as their pedagogical effectiveness.

The current study addresses this gap in the literature by examining how science practical work management practices relate to student learning outcomes in Tanzanian public secondary schools. The mixed-method research design was adopted in the study to investigate quantitative and qualitative data to develop a comprehensive picture of the influence of management practices by the teachers in enhancing engagement and performance of students in the science subject. Another aspect of the study included the perceptions of teachers and students regarding the importance of practical work.

Through the analysis of these dimensions, this research provided new knowledge to science education practice and

research. This provides evidence that even in a low-resource environment, laboratory activities can be managed effectively to substantially increase student learning results. The implications of the findings include the recommendation of teacher training, policy making, and curriculum development, as it is highly needed that more laboratory management plans and sustainable systems should be established to reinforce science education in Tanzania and other developing nations.

Theoretical Framework

The theory applied in this research is Self-Determination Theory (SDT) (Deci & Ryan, 1985) which is used to describe human motivation in terms of satisfying three important psychological needs: autonomy, competence, and relatedness. SDT can be a useful tool in science education to comprehend the role of teachers' management of practical work in promoting student motivation and academics. Students are highly motivated when they have the freedom of autonomy to explore and make choices during experiments, feel capable when guided to practice and receive feedback, and develop relatedness when they experience the creation of meaningful interactions with teachers and peers in collaborative laboratory tasks.

The only way to achieve these psychological needs is to ensure that practical work is well managed through proper planning, clear instructions, safety, and fair participation. Such environment has a positive influence on intrinsic motivation of students, their interest, and cognitive achievement (Hofstein and Lunetta, 2004; Oliveira and Bonito, 2023). Therefore, this work is supported by SDT by emphasising the potential of the management practices of teachers to promote the engagement of students, their confidence, and better results in learning science in laboratories.

Materials and methods

Research Design

The study adopted convergent parallel mixed-methods research design to investigate the impact of the management practices of science practical work on student learning outcome in the Tanzanian public secondary schools. A combination of both quantitative and qualitative data was collected and processed concurrently and separately in this design, and the findings were further combined to produce general results (Adhikari and Timsina, 2024).

The quantitative element involved descriptive, correlational, and regression comparison of the statistical links between teachers' management practices and the learning outcomes of students. The qualitative element that supported these findings was to examine the perceptions and classroom realities of the participants in terms of structured observations checklist. This triangulation approach also led to the validity of the results since the test allowed the application of quantitative and qualitative data to make conclusions (Lee, 2024).

Population and Sampling

The study was conducted in the Nyamagana and Magu districts in Mwanza Region, Tanzania, which are urban and semi-rural areas. The rationale behind the selection of these

districts was that they have similar features of Tanzanian public secondary schools. The study population comprised secondary school science teachers and science. The study included 359 participants, including 64 teachers and 295 students from 22 public secondary schools.

Schools were selected using stratified random sampling based on location and size, while simple random sampling identified student participants. Purposive sampling was used to select teachers who had been practising laboratory instructions for at least two years and were active in managing science practicals.

Data Collection Tools

This study utilised structured questionnaires and structured observation checklists for data collection. The questionnaire for the teachers was dedicated to the main areas of practical work management, such as planning, organisation, supervision, and evaluation of laboratory work. Conversely, the questionnaire for the students involved their perceptions of the effectiveness of practical work by focusing on the contribution of this kind of work to their understanding, engagement, confidence, and academic performance.

Actual practices were also noted using a structured observation checklist during science laboratory and classroom sessions. It analysed areas such as the preparation of teachers, observance of safety measures, student involvement, and utilisation of laboratory resources.

Data Collection Procedures

The data collection followed the necessity of receiving official clearance regarding the research by Tanzania Commission of Science and Technology (COSTECH) and ethical consent of the UNICAF University Research Ethics Committee. The research was conducted in accordance with the ethical principles of conducting research. Before data collection, all the participants were well informed about purpose of study, procedures and concealment of confidentiality. Teachers and students were involved on a voluntary basis and they had given their informed consent beforehand. The structured questionnaires were then distributed and collected during normal school hours to ensure high response rates and less interference with teaching schedules.

Further, classroom, and laboratory observations were conducted during scheduled science practicals. The observation time had to be between 40 and 60 min, depending on the complexity of the activity. In these sessions, data pertaining to teacher preparation, class management, student engagement, resource usage, and laboratory safety practices to obtain comprehensive and situational knowledge of how practical work was arranged and applied in actual school environments were systematically recorded.

Data Analysis techniques

The data were analysed using quantitative and qualitative techniques to obtain a general vision of the correlation between teachers' practical work management practices and the learning outcomes of the students. The statistical analysis of the quantitative data collected through the questionnaires

were performed using the Statistical Package of Social Sciences (SPSS) Version 25. Responses were summarised using descriptive statistics, such as means and standard deviations.

Pearson correlation coefficient was used to establish the magnitude and direction of the relationship between management practices and the learning outcomes of students by teachers. In addition, simple linear regression analysis was used to determine the predictive strength of the management practices of teachers on the academic performance of students in science subjects. Thematic analysis of qualitative data was founded on the field notes of observations. The data were typed, coded, and sorted into emerging themes that covered various facets of the practical work management such as teacher preparation, resource utilisation, and student interaction.

Results

This section provides the results of the research two main objectives, that were: to investigate the perceptions that teachers and students had on science practical work, and to examine the relationship between the management practices of teachers and the learning outcomes of students.

Perceptions of Practical Work

This research investigated the effects of science practical work on the learning outcomes of students from the perspectives of teachers and students. The review was directed at conceptual knowledge, problem-solving abilities, interest, self-confidence in laboratories, and academic achievement.

Teachers Perceptions of Practical Work

The teachers were asked to assess the frequency of practical work in supporting various student learning outcomes. Table 1 shows the average scores and standard deviations for each outcome.

Table 1. Teachers' Perceptions of the Impact of Practical Work on Student Learning (N = 64)

Learning outcome	Mean score	SD
Achieving learning objectives	4.38	0.51
Improved understanding of theoretical concepts	4.48	0.44
Enhanced problem-solving skills	4.29	0.63
Increased engagement in science lessons	4.31	0.58
Application of theoretical knowledge to real-life contexts	4.21	0.66
Improved collaboration among students	4.58	0.41
Enhanced scientific inquiry skills	4.31	0.53
Improved performance in summative assessments	4.27	0.60
Better retention of scientific concepts	4.44	0.49
Improved organizational skills during practical sessions	4.16	0.65
Taking responsibility for learning during practicals	4.42	0.47
Overall Mean	4.35	0.54

Scale: 1 = Never, 2 = Rarely, 3 = Occasionally, 4 = Often, 5 = Always

As observed in the responses given by teachers, there was a strong feeling that practical work was important in improving student learning outcomes. As the summary in Table 1 indicates, the total mean score of all learning outcomes was 4.35 (SD = 0.54) on a 5-point Likert scale, which means that teachers frequently or always find practical work helpful. The most positively rated benefits included an increase in the level of collaboration among the students ($M = 4.58$), better comprehension of the theoretical knowledge ($M = 4.48$), and effective fulfilment of the objectives of the learning ($M = 4.38$).

Teachers emphasized that effective and systematic practical work helps students connect theory and practice, as well as develop collaborative and problem-solving skills. This result is consistent with Hofsten and Lunetta (2004), who found that practical work enhances conceptual knowledge as well as collaborative learning.

Students' Perceptions of Practical Work

Science practical work was rated based on its benefits to students' learning ($N = 295$). Table 2 indicates the average and standard deviation of each learning outcome. Table 2 presents the means and frequencies of the responses to the primary learning outcomes.

Table 2. Student Perceptions of the Impact of Practical Work ($N = 295$)

Statement	Mean	SD
Practical lessons are linked to what is taught in theory	4.36	0.62
Understanding theoretical concepts improves after practical	4.30	0.68
Confidence in handling laboratory equipment during practical work	3.42	0.84
Demonstration of problem-solving skills during practicals	3.96	0.70
Confidence in conducting experiments	3.84	0.77
Linking theoretical knowledge to real-world applications through practical work	3.87	0.72
Improvement in academic performance due to practical work	4.05	0.69
Preparation for exams and improvement in performance through practical work	4.45	0.57
Overall mean	4.03	0.70

Scale: 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always

Students also considered practical work to be another vital science learning element. The mean score of 295 students was 4.03 (SD = 0.70), which implies that it was frequently engaged in and perceived to be beneficial. Exam preparation ($M = 4.45$) was rated as the most important, followed by the connection between theory and practice ($M = 4.36$) and enhancement of academic performance ($M = 4.05$).

Despite these positive perceptions that were experienced, weaknesses were observed. The respondents were not as confident about their ability to manage laboratory equipment ($M = 3.42$) and experiments ($M = 3.84$). This means that the students know that they need to have a practical work but they lack an opportunity to learn the practical work hence they lack confidence and the ability to learn their skills. Similar

have been found by Ajani (2023), who observed that African schools possess very few resources and a large number of students in classes, which does not allow them to conduct experiments in the classroom.

Qualitative Discoveries through Classroom observations

The observation material contained further data on the application of the practical work to the school practise. Three key themes were identified in the interviews.

Active Engagement and Motivation

Students had more interest and attention span towards practical sessions which involved active participation. Materials were used and experiments were actively engaged in to make them more interested and committed to the process of learning. These notes are consistent with the constructivist principles of learning, according to which, active engagement is quite essential in the process of knowledge building.

Barriers to Effective Practice

Insufficient laboratory resources were the main occurring challenges in different schools. In most schools, learners were made to share limited equipment, and as such, some students could not conduct experiments as they could only observe. Large class size and lack of facilities were also a further drag on personal involvement and the quality of overall practical learning experiences.

Perceived Academic Value

Both students and teachers related practical work to passing exams. Some of them warned that excessive emphasis on examinations would diminish inquiry-based learning. The teachers noted the necessity of balancing the process of preparing students for tests and causing them to think more powerfully and scientifically. The qualitative outcomes can be added to the quantitative ones, and the conclusion is that although practical work is valued, its effectiveness is constrained by contextual and structural issues.

Relationship Between Management Practices and Learning Outcomes

To explore the relationship between teachers' management practices and students' learning outcomes, Pearson's correlation analysis was conducted (Table 3).

Table 3. Correlation Between Practical Work Management and Student Outcomes

Variables	Teachers' practices	Students' Outcomes
Teachers' practices	1.000	0.734*
Students' Outcome	0.734*	1.000
Sig. (1-tailed)		0.010

Note: $p < 0.01$, two -tailed

Pearson's correlation coefficient quantitative analysis showed that the relationship between the management practices of the teachers and the learning outcomes of the stu-

dents is strong and positive ($r = 0.734$, $p < 0.010$). This means that proper planning, practical activities, and organization are linked to better student performance in science.

In the investigation of the effect of practical work management on student learning, simple linear regression was employed to analyze the power of predicting the outcome of students in the view of the management practices of teachers. The results are presented in Table 4.

Table 4. Regression on Practical Work Management and Learning Outcomes

Predictor	B	SE B	β	t	p
Constant	0.752	0.483	–	1.56	0.215
Teachers' Practices	0.812	0.180	0.834	4.52	0.010*

$R^2 = 0.87$, Adjusted $R^2 = 0.86$, $F_{(1,62)} = 20.46$, $p < 0.01$

Pearson's correlation coefficient quantitative analysis showed that the relationship between the management practices of the teachers and the learning outcomes of the students is strong and positive ($r = 0.734$, $p < 0.010$). This means that proper planning, practical activities, and organization are linked to better student performance in science. In the investigation of the effect of practical work management on student learning, simple linear regression was employed to analyze the power of predicting the outcome of students in the view of the management practices of teachers. The results are presented in Table 4.

Moreover, the analysis based on simple linear regression proved that management practices of teachers are a significant predictor of student learning outcomes ($\beta = 0.834$, $p < 0.010$), and $R^2 = 0.87$ indicates that 87 percent of the variation in student outcome is explained by management practices. The regression coefficient ($B = 0.812$) indicates that the learning outcomes of students would improve by approximately 0.81 units as the practice of effective management increases by one unit.

This observation has solid empirical support, as the management of practical work can significantly influence students' performance. This is consistent with the findings of Efendi and Jayanti (2024) and Apeadido et al. (2024), who established that schools with stronger laboratory management and teacher readiness always have high academic performance. The findings also support the fact that management practices are not only structural but also pedagogical determinants of learning. Organisationally, a well-organized laboratory presents fair access to materials and safety; pedagogically, it is clear, guides, and provides an incentive to learn actively. On the contrary, the lack of good management promotes a lack of organization, disengagement of students, and a lack of conceptual knowledge.

Discussion

The results of this study are consistent with universal and local studies on the importance of applied activities in supporting conceptual learning and inquiry knowledge (Hofstein and Lunetta, 2004). The academic awareness of the educative importance of working practice was common in this research among teachers and students, particularly in connecting theory with practice and enhancing test scores.

Nevertheless, some unending obstacles that exist in the form of poor facilities, lack of equipment, and large class size

keep impeding successful execution. These findings are consistent with those of Kinyota (2020) and Mwakalinga (2021), who also found the same limitations in Tanzanian schools. The poor confidence of students in relating with laboratory equipment is a sign that even though they are required to do practical learning, they have not done it adequately as per the curriculum requirements.

It is important to note that this study provides new empirical findings according to which the management practises of teachers are quite good predictors of student learning outcomes. This demonstrates the significance of teacher preparation, planning and organisational competence in maximising the benefits of laboratory-based learning. Through appropriate management strategies, including application of rotating groups, improvising teaching resources, and peer to peer co-operation, the instructors in the learning environments that are of low resource endowment can achieve high learning achievements.

The qualitative results support the notion that the level of interest of students in practical lessons is high, and unless the resources and instructions are provided, the interest level cannot be converted into tangible learning outcomes. The research thus shows that one of the critically important levers for improving the quality of science education in Tanzanian secondary schools is the enhancement of management practices and systems of teacher support.

Conclusions

This research proved that practical work in science can be well managed to promote learning outcomes among students in Tanzanian secondary schools. Teachers and learners considered applied lessons important for the acquisition of science, boosting problem-solving ability, and academic achievement. The quantitative findings supported a high positive correlation between the management practice of teachers and the achievement of the students, while the qualitative findings identified the benefit of the engagement and the constant obstacles, including poor facilities and crowded classes. Altogether, the research concludes that the quality of science education can be significantly enhanced by enhancing the competence of teachers who must cope with laboratory activities, even in under-resourced settings.

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Data Availability

The data are not publicly available due to ethical or privacy restrictions; anonymized data may be provided upon reasonable request.

Conflict of Interest

The authors declare no conflicts of interest.

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Вплив практик управління практичними роботами з природничих наук на результати навчання учнів

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 7 с., 4 табл., 15 джерел.

Мета. Дослідження спрямоване на вивчення впливу практик управління практичними роботами з природничих наук на результати навчання учнів у державних закладах середньої освіти Танзанії. Метою роботи було визначити роль учителів в організації та контролі лабораторної діяльності з точки зору її впливу на академічну успішність та інтерес учнів до природничих дисциплін.

Матеріали і методи. У дослідженні використано конвергентний паралельний дизайн змішаних методів, що передбачав одночасне поєднання кількісних і якісних даних. У вибірку увійшли 64 вчителі природничих дисциплін і 295 учнів із 22 державних закладів середньої освіти округів Ньямагана та Магу. Збір даних здійснювався за допомогою анкетування та структурованих спостережень за навчальними заняттями. Для аналізу кількісних даних застосовувалися описова статистика, кореляційний аналіз Пірсона та лінійна регресія в програмному забезпеченні SPSS (версія 25). Якісні дані опрацьовувалися методом тематичного аналізу з метою доповнення статистичних результатів.

Результати. Отримані результати засвідчили наявність сильної позитивної кореляції між практиками управління практичними роботами з природничих наук і результатами навчання учнів ($r = 0,734$; $p < 0,010$). Регресійний аналіз показав, що академічна успішність учнів значною мірою прогнозується практиками управління, які застосовують учителі ($\beta = 0,834$; $p < 0,010$). Кількісні результати були підтверджені якісними даними, які свідчать про підвищення впевненості та рівня концептуального розуміння учнів завдяки ефективній підготовці вчителів, раціональній організації ресурсів і активному залученню учнів до навчального процесу. Водночас суттєвими обмеженнями були виявлені недостатня матеріально-технічна база та переповерхненість класів.

Висновки. Дослідження показало, що належним чином організована практична робота з природничих наук суттєво покращує результати навчання учнів, сприяючи їх залученості, мотивації та формуванню глибокого концептуального розуміння. Для підвищення якості природничої освіти, особливо в школах з обмеженими ресурсами, доцільно посилювати професійні компетентності вчителів у плануванні та проведенні лабораторних занять.

Ключові слова: практичні роботи з природничих наук, управління лабораторною діяльністю, результати навчання, педагогічні практики, державні середні школи Танзанії.

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