PRACTICES AND CHALLENGES IN IMPLEMENTING CHEMISTRY LABORATORY WORK IN SECONDARY SCHOOLS: A REVIEW

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ABSTRACT

Laboratory work in secondary schools plays a paramount role in the teaching and learning process of practical activities, aiding students' understanding of chemical concepts and experimentation. This review aimed to assess the practices and challenges of implementing chemistry laboratory work in different secondary schools in developing countries. The most recent and reputable journal publications were examined and utilized as primary sources. Fifteen studies, gathered through Google Scholar and Eric databases in the time frame from 2016 to 2024, were selected for review. Findings indicate that significant challenges, including shortages of laboratory apparatus, chemicals, and trained technicians, inadequate storage facilities, and limitations in laboratory infrastructure. These challenges hinder effective teaching and learning of chemistry, impacting students' academic achievement and attitudes towards science. Despite positive perceptions towards practical work, resource constraints and other factors limit its implementation. Curriculum expectations often differ, and practical constraints often hinder hands-on learning. Effective collaboration among stakeholders, including educational authorities, policymakers, school administrators, and teachers, is important for enhancing students' learning experiences and promoting scientific literacy. *[African Journal of Chemical Education—AJCE 14(2), May 2024]*

INTRODUCTION

Chemistry is a branch of natural science that focuses on understanding the composition, properties, and change of matter [1]. This educational domain not only imparts theoretical knowledge but often complements it with practical laboratory experiments, giving students a tangible grasp of the concepts [2]. Since science was included in the curriculum of education in many countries in the late nineteenth century, practical activity has played a significant role in science education [3].

The integration of laboratory activities into the curriculum reflects a pedagogical shift towards active learning methodologies, aiming to move beyond rote memorization towards more experiential forms of knowledge acquisition. Furthermore, practical work serves as a bridge between theoretical knowledge and real-world applications, providing students with tangible experiences that enhance their engagement and retention of scientific concepts [4].

Laboratory equipment in chemistry provides students with hands-on experience, allowing them to directly engage with the data they collect. Educators found that having access to proper laboratory supplies facilitates teaching and learning for both teachers and students. For instance, [5-6] found that active participation in practical laboratory work enhances students' academic achievements and fosters positive experiences and perceptions. Many scientific theories and

concepts are challenging to grasp solely through theoretical explanations in textbooks. However, conducting practical experiments offers a tangible way for students to easily comprehend complex scientific theories [7]. For instance, chemical equilibrium in chemistry is a dynamic concept that can be challenging for students to understand without practical experience, in the classroom [8].

Practical work, as described by [9], develops problem-solving skills and enhances conceptual understanding in learners. Moreover, practical work aims to enhance students' comprehension, problem-solving skills, and understanding of chemistry by emulating the actions of scientists. By engaging in hands-on experimentation, students not only gain a deeper understanding of theoretical concepts but also learn to think like scientists, systematically approaching problems, analyzing data, and drawing conclusions [10].

Studies showed that practical work enhances students' communication skills, enables them to tackle scientific problems effectively, and boosts their motivation in the field of science [4]. For example, when students conduct experiments involving titration, they witness firsthand the precise measurement of volumes and the chemical reactions that occur between solutions of known concentrations, and they understand that chemistry is an applied science.

As [11] suggested, practical work should be viewed as the mechanism by which materials and equipment are carefully and critically brought together to convince the learner about the

accuracy and truthfulness of the scientific worldview. When implemented effectively in early secondary school, practical work in science, particularly in chemistry, develops critical thinking skills.

However, [12] argues that practical work in education can be ineffective when it requires students to merely follow instructions without engaging in critical thinking or creativity. As a result, practical work might fail to achieve its educational goals and could be perceived as a waste of time. Implementing discovery and inquiry-based assignments within laboratory programs has the potential to enhance students learning outcomes. It is not necessary to change the experiments themselves, but the way they are used. Allowing students to develop their own strategies, creating a unique learning environment that encourages both hands-on and mind-on activities [13].

As highlighted by [14], laboratory work distinguishes itself with its hands-on and experimental nature, providing students with a platform to go beyond theoretical concepts and explore practical applications. Practical activities are vital in secondary school science education, particularly in chemistry, biology, and physics, as they help students understand theoretical knowledge [6].

Chemistry, being inherently an experimental science, relies heavily on laboratory activities for its comprehension and application [11]. Through hands-on experiences, students not only

develop process skills but also actively construct knowledge by engaging with materials, thereby enhancing their problem-solving abilities [15]. Chemistry without laboratory work is often perceived as a mere collection of factual information and general laws that fail to deeply engage the mind [16]. Practical experiences in the school laboratories are essential for making chemistry fully meaningful to students [14]. It is evident that chemistry encompasses both theory and practice, and, therefore, requires instructional laboratories designed to support and enhance the exploration and synthesis of both ideas and materials [5].

In secondary school, each student should take full responsibility for conducting experiments to enhance understanding of scientific concepts, foster critical thinking, develop problem-solving skills, and instill a sense of ownership [17]. However, research indicates that in the absence of laboratories, chemicals, and reagents, teachers often prefer lecture-based methods. This “chalk and talk” approach to chemistry education limits student participation, rendering them passive observers and resulting in low acquisition of scientific skills and knowledge [18]. Meaningful learning in the laboratory would occur if students were given ample time and opportunities for interaction and reflection. The instructional theory of learning interaction asserts that chemistry laboratories directly influence students' attitudes and academic performance. This notion stems from the fundamental

idea that regular practice leads to perfection [19]. Constant practice is often believed to enhance proficiency in what a learner learns during classroom instruction.

Furthermore, researchers and educators consistently emphasize the numerous benefits of laboratory activities in science education. In a well-designed laboratory environment, students engage in hands-on activities to gather data, explore concepts, create experiments, and physically manipulate substances. This approach fosters immediate connections and involves their interest and active participation. In addition, laboratories are central to science learning, actively engaging students in the process of identifying scientific problems, formulating hypotheses, designing experiments, gathering and analyzing data, and drawing conclusions about various phenomena [5, 20, 21].

Multiple research studies have pointed out various interpretations of practical work, often using the term "laboratory work" interchangeably with "practical work." Laboratory work typically refers to experiments conducted within a laboratory setting. This often involves the use of equipment and following specific procedures to investigate scientific phenomena. On the other hand, "practical work" encompasses a broader range of activities in which concepts taught in the classroom are linked to real practice in the laboratory or outside the laboratory. While laboratory work is a common form of practical work, it can also extend beyond the laboratory setting. Practical work can involve

fieldwork, demonstrations, simulations, or even projects that require students to apply theoretical concepts in practical contexts [22].

Moreover, [23] defines a science laboratory as a workshop where scientific activities are conducted in a conducive environment, serving as a secure space for storing equipment and materials. Furthermore, laboratory work is often characterized by collaborative learning environments, where students engage in group experiments, discussions, and peer-to-peer interactions.

This collaborative setting not only enhances teamwork skills but also encourages communication and the exchange of ideas among students [4].

Chemistry is a fundamental subject that applies to various careers and opportunities, as described by [24]. Careers such as chemical engineering, medicine, pharmacy, food science, and environmental studies all benefit greatly from a strong foundation in chemistry. Moreover, chemistry education serves as a cornerstone for national development, influencing crucial sectors such as medicine, food, agriculture, environmental protection, textiles, and cement production [25]. Recognizing this, policymakers, educators, and parents advocate for students to gain practical knowledge of science and technology, particularly through hands-on laboratory experiences. Such

knowledge not only prepares students for the demands of the contemporary workforce but also equips them to make informed decisions and contribute meaningfully as engaged citizens [13].

In secondary schools, the quality of teaching and learning experiences is significantly shaped by the adequacy of laboratory facilities and the effectiveness of teachers in utilizing these resources to facilitate meaningful learning for students. Research conducted by [26-28] indicates that the quality and sufficiency of laboratory facilities significantly affect students' academic performance in science subjects, particularly chemistry, as well as the teacher's ability to use them effectively. Hence, a teacher's skill in utilizing laboratory resources for meaningful and engaging learning experiences is paramount to achieving successful learning outcomes. Furthermore, teachers should possess knowledge not only of the theoretical aspects but also of practical procedures and student activity management, aligning the curriculum with their instructional methods and incorporating laboratory experiences [21].

For instance, [29] observed a positive and significant correlation between students' achievement in chemistry and the quality of laboratory resources, including apparatus, chemicals, and practical exercises. Likewise, [30] investigated the impact of laboratory facilities on students' academic performance in chemistry, and the findings revealed that the utilization of these resources

significantly influenced student achievement. This suggests that it is not possible to fully implement the teaching and learning of chemistry in a secondary school without a well-equipped laboratory. However, studies revealed that chemistry laboratories in developing countries are commonly characterized by a poor standard of education, resulting from various factors including a lack of trained and skilled manpower, inadequate facilities, limited financial resources, and constraints in laboratory design and technical support [18, 31].

Therefore, the objective of this review was to investigate the current status of laboratory facilities, resources, and practices in secondary schools in developing countries, with a particular focus on chemistry education. The review aims to highlight the challenges and constraints faced by both teachers and students in accessing and utilizing laboratory equipment, chemicals, manuals, technician support, storage practices, and infrastructure. Additionally, it seeks to explore the perceptions of both students and teachers towards laboratory work.

METHODOLOGY

Our study utilized a desk review methodology to gather pertinent information for the research review. Desk reviews involve scrutinizing existing research findings conducted by other scholars, making them significant for addressing our research topic. The data collection process relied on

internet exploration via academic databases such as Google Scholar and ERIC to identify studies relating to the topic. To ensure rigor, the following selection process and methodology were used:

- Google Scholar and ERIC databases served as primary sources for academic literature due to their extensive coverage of scholarly articles in the field.
- A targeted search strategy involves utilizing keywords and phrases like "chemistry laboratory work in secondary schools," "secondary school chemistry experiment," and "chemistry laboratory practices in secondary school" to identify relevant studies.
- The screening process commenced with the evaluation of study titles and abstracts to determine their relevance.
- Full-text articles were prioritized for inclusion.
- Studies conducted at the secondary school grade level were prioritized.
- Preference was given to studies published in reputable journals, with exclusion criteria applied to those from predatory journals.

Out of a total of 50 studies initially explored and analyzed, 20 articles were excluded, conducted in higher institutions and primary schools, that did not directly address our selected topic. Additionally, we eliminated 10 outdated articles and 5 non-reputable sources from consideration. Ultimately, 15 studies meeting our inclusion criteria were deemed eligible for this review. These

studies, published between 2016 and 2024, addressed the practices and challenges of implementing chemistry laboratory work in secondary schools.

RESULTS AND DISCUSSIONS

Availability and Condition of Laboratory Equipment

The subject of chemistry requires sufficient equipment and laboratory facilities since various physical and chemical processes and reactions integral to the subject cannot be adequately understood solely through theoretical explanations. Laboratory apparatus and equipment are essential tools used in scientific experiments across various fields, such as chemistry, biology, and physics. These facilities communicate explicitly to clarify concept, knowledge and facilitate understanding for learners. The required facilities vary based on factors such as the nature of the study, grade level (e.g., high school), and the specific experiment's requirements.

Laboratory apparatus are crucial tools for students in various disciplines like chemistry and biology, enabling experimentation, data collection and data analysis, which are essential for knowledge advancement. For instance, [29] found that the quality and adequacy of laboratory facilities significantly influence academic performance in science disciplines, particularly chemistry. These studies indicate that students' access to well-equipped and functional laboratory resources is

positively correlated with their ability to comprehend scientific concepts, effectively conduct experiments, and ultimately achieve higher academic proficiency in chemistry. Conversely, insufficient laboratory facilities resulted in poorer performance.

A study investigating the constraints faced by teaching and learning chemistry in secondary schools in Nyarugenge district, Rwanda, revealed that 58.4% of the schools lacked a chemistry laboratory apparatus and chemicals. Additionally, in cases where laboratories were available and adequately equipped, it was found that they lacked essential requirements such as a fume chamber, safety equipment, gas taps, running water, and chemicals. Furthermore, the study established that the primary activities conducted in these laboratories were teacher demonstrations [32]. Furthermore, research conducted Rwandan secondary schools indicates that the successful implementation of effective chemistry teaching was hindered by various factors, such as a shortage of chemistry chemicals and equipment, and insufficient time allocated to chemistry on the timetable [33].

Another study conducted on the availability and utilization of laboratory facilities for teaching carbohydrates in senior secondary schools in the Uyo education zone, Akwa Ibom State, Nigeria, revealed that few laboratory facilities were available but were rarely utilized by biology and chemistry teachers [34]. Despite the presence of some laboratory facilities, biology and chemistry

teachers are not utilizing them effectively because science teachers are not well equipped to deliver quality instructions since they lack adequate training on the use of instructional facilities. This indicates a significant gap in providing students with practical, hands-on learning experiences essential for a comprehensive understanding of scientific concepts.

Practical works in secondary schools in Ethiopia are also studied to identify factors hindering its proper implementation. A survey, conducted in Adet and Deberemewii secondary schools in the Amhara region found that 92.7% and 90.6% of the schools, respectively, lack adequate chemistry laboratory chemicals for grades 9 and 10. These schools face challenges in acquiring essential laboratory equipment, chemicals and safety gear, and suffer from a shortage of lab technicians [18]. Without sufficient resources, conducting meaningful and effective laboratory experiments becomes difficult, leading teachers to rely more on theoretical instruction. Furthermore, secondary schools encounter various challenges related to their physical facilities, including overcrowded laboratory rooms, issues with water supply and electrical installations, and insufficient space for students during laboratory activities [35].

Moreover, the study on the status of the chemistry laboratory and practical activities in secondary schools in East Gojjam, Ethiopia, as reported by [36], indicated that both grade 9 and 10 students never did practical work in the lab. The main reasons indicated in the findings were the lack

of chemicals and apparatuses, fear of chemicals, lack of administration support, poor organization of the lab, no time allotted for practical lab work, and lack of laboratory training on how to use the laboratory to teach chemistry. Similar studies conducted in different areas of Ethiopia indicated that the implementation of laboratory work was difficult due to the lack of laboratory facilities and equipment [37-39]. However, there were schools like Debre Markos preparatory school with moderately equipped facilities [40]. Nevertheless, the implementation of practical work was hindered by a lack of motivation among teachers and support from school administrates.

The Development and Utilization of Chemistry Laboratory Manuals

Laboratory manuals serve as indispensable resources in chemistry laboratories, providing step-by-step procedures, safety precautions, and essential information for conducting experiments accurately and efficiently. Teachers typically guide students through topics, connecting them to previous lessons, and students then follow the outlined steps. This cookbook approach is widely used by teachers, focusing on clear, predetermined outcomes. By following these manuals, students can save resources such as time, equipment, and materials, as multiple students can perform the same activity [41-42]. Furthermore, [43] suggested that laboratory manuals play a significant role for most teachers and students in defining goals and procedures for laboratory activities.

However, critics argue that relying solely on cookbook-style labs may stifle creativity and innovation, as students are directed too closely by exacting instructions, potentially hindering critical thinking and exploration [44]. Additionally, students may struggle to achieve effective learning outcomes when they solely rely on laboratory manuals, as these resources often lack real-world connections. [45-46] assert that while students using laboratory manuals tend to prioritize adherence to instructions, they may not develop their capacity to question, design, conduct, and analyze experiments effectively. This focus solely on scientific terminology can limit students' understanding, preventing them from seeing beyond what is happening during experiments.

Furthermore, [47] advocate for a departure from traditional lecturing and cookbook-style laboratories towards active learning strategies such as problem-based learning, cooperative learning, and inquiry-based learning. These methods aim to support students in developing their cognitive processes and foster lifelong learning. Particularly, inquiry-based learning allows students to apply their knowledge, comprehend real-world situations, and engage in discovery.

For instance, the Ministry of Education in Rwanda has developed a comprehensive chemistry laboratory manual for secondary schools titled "Chemistry laboratory manual for secondary schools in Rwanda." This manual was designed to guide students and teachers through various experiments and practical activities in the field of chemistry. However, research indicates that many secondary

schools, both rural and urban, face shortages of laboratory manuals [32]. Similarly, in Nigeria, one of the laboratory-related factors identified for the implementation of practical work was the lack of instructional materials such as laboratory guidance and insufficient time allocated for practical work [48].

Ethiopian secondary schools did not have practical guides or laboratory manuals for chemistry education. Effectiveness in chemical laboratory instruction requires that learners be provided with practical guides. These resources provide a wide range of practical activities together with detailed procedures to be followed, which, as a consequence, boost practical instruction. To practice laboratory experiments, there were no well-prepared laboratory manuals, and practical activities per week were not specified in the syllabus or textbooks [35]. The absence of laboratory manuals in secondary school chemistry can put pressure on teachers to write down procedures on the chalkboard. Furthermore, the lack of practical manuals in chemistry may result in learners not perceiving practical work as important.

Storage and Organization of Laboratory Apparatus and Chemicals

Proper storage of chemicals and apparatus ensures the safety and accessibility of chemicals and equipment for laboratory users. Effective storage practices not only prevent accidents but also

contribute to the longevity of equipment and facilitate efficient access during experiments. Chemistry, as a subject, provides one of the most pedagogically sound learning environments that results in potentially dangerous situations for students and teachers in the school environment [49]. The chemistry laboratory serves as a center for students to develop skills, conduct experiments, and interpret experimental data. Lack of knowledge about storage and labeling of chemicals can impact the health of students and teachers, as well as the environment [50]. Incompatible chemicals should be kept separate during storage, use, and disposal; these chemicals may explode or become highly toxic if they come into contact [51].

Research conducted by [52] in selected secondary schools in Kebbi State, Nigeria, revealed improper storage of chemicals and apparatus due to a shortage of separate rooms, lockers, and refrigerators, as well as a lack of lab technicians. Similarly, a survey conducted by [53] in Finote Selam town of secondary schools in Ethiopia found that some materials and equipment were locked up in the school laboratory store without teachers being aware of their existence. Additionally, even when chemicals and apparatus were present in some quantity, laboratory rooms had limited functionality. Moreover, in the Amhara region, particularly at Adet and Debremewii secondary schools, challenges were faced regarding the improper storage and organization of chemicals and

apparatus. These challenges included the improper labeling of chemicals, incorrect storage of reactive chemicals, and inappropriate placement of glassware with metals [18].

Another study conducted in secondary and preparatory schools in East Gojjam, Amhara region, and in Wolaita zone, Southern Ethiop, revealed that improper storage of laboratory equipment and chemicals was found. The equipment and chemicals were not organized and stored in their respective places according to storage methods and rules and regulations [35-36]. This lack of organization can lead to health hazards, accidents, and environmental damage. High school chemistry laboratories have a detailed external and internal set-up; laboratory facilities are available at an acceptable level in terms of quality as well as quantity, including the arrangement of chemicals and adherence to technical guidelines for lab safety and safety materials [54].

Technician-related Challenges in Chemistry Laboratories

Numerous research studies have emphasized the pivotal role of laboratory technicians in facilitating effective science instruction and practical learning experiences [18, 55]. A qualified laboratory technician plays a vital role in a chemistry laboratory, performing tasks such as setting up and maintain equipment, preparing chemicals and materials for practical work, adhering to safety procedures, accurately labeling of chemicals, and providing technical support to teachers [55].

However, research indicates that many secondary schools struggle to recruit and retain skilled laboratory technicians due to various factors such as low salaries, limited career advancement opportunities, lack of recognition, job market shortages, and budget constraints [32, 35, 55].

For instance, in Tanzania, a study conducted in ten secondary schools indicated that in eight schools, 80% did not have qualified laboratory technicians. This impacted the successful implementation of chemistry teaching and the management of chemicals and apparatus [55]. Furthermore, a survey conducted in Rwandan secondary schools in Nyarugenge showed that the lack of laboratory apparatus, chemicals, and qualified laboratory technicians, were the major constraints faced in teaching and learning chemistry [33].

Similarly, a study conducted in the Woliata zone of Southern Ethiopia regarding the availability of trained laboratory technicians in secondary schools found that 70% of secondary schools reported a lack of trained laboratory technicians. The major reason cited for the absence of laboratory technicians was the lack of trained professionals in the job market and budget constraints [35]. This trend was not exclusive to the Woliata zone, as evidenced by parallel studies conducted in Adet and Debremewii secondary schools in the Amhara region, as well as in Finote Selam town, Amhara region, Ethiopia. Additionally, research conducted in preparatory schools in the North

Shewa zone Ethiopia found that 64.5% of the schools lacked trained laboratory technicians, which negatively impacted students' academic achievement in chemistry [56].

The Laboratory Room Infrastructure

The laboratory is a designated space for conducting science experiments, demonstrations, and investigations, specifically designed for learning and teaching scientific concepts [57]. Through laboratory experiences, students can apply theoretical knowledge from their textbooks to practical realities, thereby deepening their understanding of learned concepts. Laboratories should not merely serve as spaces to present textbook phenomena and confirm established principles and law, but also provide students with the chance to engage in independent scientific inquiry processes [4]. Farombi (1998), as cited by [27] argued, that the saying "seeing is believing" emphasizes the significant impact of laboratories on the teaching and learning of science disciplines. Students are more likely to understand and retain concepts when they observe them firsthand rather than solely relying on verbal explanations. Science practices predominantly take place in laboratory settings, making them an important resource for teaching science, particularly chemistry, and serving as important predictors of academic achievement [58].

In many African countries, it is common practice to utilize single science laboratory rooms for all sciences, thereby limiting practical activities for each discipline [48]. For instance, a study conducted in public secondary schools in Arumeru district, Tanzania, revealed that 55% of schools have only one science laboratory, with 22% having two and 22% having three, indicating a shortage of the required three for biology, chemistry, and physics, which in turn affects teaching efficiency. Similarly, a survey study conducted in secondary schools in Nyarugenge district, Rwanda, reported that a shortage of separated laboratory rooms for biology, chemistry and physics, and small classroom sizes were identified as challenges [33].

Furthermore, research conducted in the Woliata zone in Southern Ethiopia revealed that secondary schools had only a single laboratory for all three science subjects, significantly limiting practical activities and impeding students' hands-on learning experiences [35].

In contrast, another study conducted in the Adet and Debremewii secondary schools of the Amhara region indicated the presence of separate laboratories, with one specifically dedicated to chemistry [18]. Additionally, a study in the West Arsi zone, Oromia region, Ethiopia, revealed that the laboratory rooms were too small to accommodate all students and were unsuitable for work due to various deficiencies. The laboratories were found to be below standard, lacking basic facilities

such as running water, a source of electricity, sinks, fume hoods, and having broken windows, roofs, and doors, making insecure places in which to keep materials and conduct experiments [39].

The Perception of Students in Laboratory Work and Their Teachers

The development of teachers' favorable attitudes toward science has often been identified as a key objective in science education. Research suggests that students generally enjoy laboratory work, which tends to result in more positive attitudes toward science and increased interest in the scientific discipline [43]. Hands-on learning in a chemistry laboratory boosts students' positive attitudes towards the subject, leading to a passion for science [38]. The perceptions of both students and teachers regarding laboratory work are crucial, as students' perceptions of the learning environment, particularly in laboratory settings, significantly influence their experiences and outcomes.

As highlighted by [59], these perceptions significantly influence how and what students learn, emphasizing the need to understand their perspectives regarding the purpose and role of laboratory work in instruction. Therefore, gaining insight into students' perceptions of the laboratory from the teacher will provide valuable insight into what students are capable of achieving in the

laboratory. According to [60] laboratory activities stimulate the acquisition of scientific attitudes such as honesty, open-mindedness, and cooperation, which are essential ethical values in science.

A study conducted in secondary schools in Nyarugenge district, Rwanda, revealed that teachers exhibited a positive perception of incorporating practical chemistry lessons. They believed that practical work enhances students 'conceptual understanding and fosters participation, confidence, motivation, and problem-solving skills. Additionally, all students reported that learning chemistry through practical work was interesting, joyful, and easy to understand when they engaged in experimentation. This positive attitude toward chemistry during practical work sessions indicates that their academic achievement improved as a direct result of practical teaching [33]. Similarly, a study of secondary schools in the North Wollo zone, Ethiopia, conducted by [38], indicated that both students and teachers perceived chemistry practical experiments as relevant to students' learning. However, despite its relevance, the study revealed that the practice of laboratory work was very low due to a lack of resources such as laboratory equipment, time constraints, and students' administrative engagement. Another study in secondary schools in Finote Selam town, Amhara region, Ethiopia, showed that teachers lack commitment, interest, and even skill to conduct laboratory activities in the laboratory [53]. However, in a study conducted by [61] in selected preparatory schools in the Afar region of North-East Ethiopia, teachers and students' attitudes

toward practical laboratory work were diversified. Some instructors eagerly endorse its implementation, while others hold reservations due to constraints related to available resources, safety concerns, or insufficient training.

CONCLUSION AND RECOMMENDATIONS

Implementing chemistry laboratory work in secondary schools faces several challenges and practices that significantly impact students' learning experiences. The availability and condition of laboratory equipment play a crucial role, with inadequate resources hindering students' academic performance. Additionally, the lack of laboratory manuals affects laboratory work. Proper storage and organization of laboratory apparatus and chemicals are essential for safety and accessibility, yet many schools struggle with these practices. Moreover, the shortage of skilled laboratory technicians further complicates the smooth operation of chemistry laboratories. Infrastructure limitations, such as insufficient laboratory rooms, also pose obstacles to conducting effective practical activities. Despite these challenges, both students and teachers generally perceive laboratory work positively, recognizing its importance in enhancing conceptual understanding and fostering scientific skills.

To address these issues and enhance the quality of chemistry education, the following, recommendations are proposed:

- Allocate sufficient financial resources to secondary schools to ensure they meet the standards required for practical chemistry instruction.
- Develop capacity-building programs to empower teachers to adapt experiments to local contexts, encompassing both theoretical understanding and practical application of indigenous resources.
- Develop and distribute standardized laboratory manuals providing detailed procedures, safety precautions, and explanations to enhance the effectiveness and consistency of laboratory sessions.
- Implement a dedicated schedule for laboratory activities, allowing students adequate time for hands-on experimentation.
- Recruit and train qualified laboratory technicians to oversee and assist with laboratory activities, ensuring proper management and maintenance of resources.
- Promote student interest and involvement in laboratory work, encouraging active participation and fostering critical thinking skills.
- Facilitate the sharing of laboratory resources between universities and secondary schools to enrich the learning environment.

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