



Received : 31 October 2025
Revised : 10 February 2026
Accepted : 29 May 2026
Published : 31 May 2026
Page : 35 - 49

Analysis of Chemistry Laboratory Management at Sultan Iskandar Muda Senior High School Medan

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Abstract: *This study aims to describe the management of the chemistry laboratory at Sultan Iskandar Muda Private Senior High School in Medan. Using a descriptive qualitative approach through observation, interviews, and documentation, the findings reveal that laboratory management has generally met standard criteria, including well-organized layout, systematic administration, proper management of equipment and chemicals, and adequate implementation of occupational health and safety (OHS). However, several aspects such as digital-based administration, structured waste management systems, and supporting facilities still require improvement. These findings contribute to the development of integrated and standard-based chemistry laboratory management in schools, particularly by emphasizing the importance of aligning management, administration, and safety practices to enhance laboratory effectiveness and sustainability.*

Keywords: *laboratory management; occupational safety; chemical substances; laboratory waste.*

INTRODUCTION

Educational success is a strategic objective that directly contributes to a nation's development. In the context of chemistry learning, the teacher's role is not only as a transmitter of concepts but also as a manager of a practice-based learning environment that is safe and standardized. The development of Science Process Skills (SPS) requires active student involvement through structured and controlled experimental activities. The effectiveness of practical activities is strongly influenced by the quality of laboratory management, which includes planning, organizing, implementing, and evaluating laboratory activities. In addition, the

implementation of occupational health and safety (OHS) is an essential component in ensuring students' safety during laboratory activities (Samiun & Nuryanti, 2022).

In modern education, the laboratory is no longer viewed merely as a space for practical work, but rather as an integrated system that includes facility management, administration, safety practices, and institutional policies. Effective laboratory management has been shown to have a significant relationship with the improvement of learning quality and student achievement. Policies related to educational facility management also play an important role in ensuring the sustainability of laboratory

functions as a medium for experiment-based learning. However, most previous studies have primarily focused on the use of laboratories as learning media without deeply examining managerial aspects. (Emda, 2017). The function of the chemistry laboratory as a bridge between theory and practice can only be optimized when supported by a systematic and standards-based management system. The implementation of OHS principles is crucial in creating a safe and conducive learning environment. The low implementation of safety standards can increase the risk of accidents and hinder the effectiveness of laboratory-based learning. Therefore, the integration of laboratory management and OHS implementation should be a primary concern in managing educational laboratories (Ramadhani, 2020).

From an administrative perspective, laboratory management includes inventory systems for tools and materials, usage records, and structured control of chemical stocks. Proper laboratory administration enables efficient use of resources and minimizes errors in the implementation of practical activities. Furthermore, the existence of standard operating procedures (SOPs) and regulations governing laboratory use is an essential part of educational facility management policies. Without a well-organized administrative system, laboratory utilization tends to be suboptimal and may pose safety risks (Emda, 2017). Research published in the Journal of Innovation in Chemistry Learning indicates that laboratory management influences the improvement of students' science process skills. Another study shows that the implementation of effective laboratory administration systems can enhance the effectiveness of chemistry practical activities. In addition, laboratory management based on OHS has been proven to increase students' awareness of safety during experimental activities. Other research also emphasizes that clear laboratory management policies contribute to the smooth implementation of practical work. However, these studies still tend to be partial and have not comprehensively integrated aspects of

management, administration, and OHS (Samiun & Nuryanti, 2022). Based on this literature synthesis, there is a research gap indicating that studies on chemistry laboratories are still dominated by pedagogical approaches and have not extensively examined managerial aspects in an integrated manner. Previous studies tend to separate laboratory management, administration, and OHS implementation without considering the interrelationship among these aspects. In fact, the integration of these three aspects is essential in creating an effective, safe, and sustainable laboratory system. Therefore, this study positions itself as an effort to holistically examine the relationship between laboratory management, administrative systems, and OHS implementation in supporting the effectiveness of chemistry learning (Emda, 2017).

Overall, professional and standards-based laboratory management not only improves the efficiency of facility utilization but also ensures safety and order in the learning process. A well-managed laboratory serves as a key supporting system in creating meaningful and sustainable chemistry learning. Thus, the integration of laboratory management, administration, facility management policies, and OHS implementation is the key to optimizing the function of educational laboratories (Gusmanto, 2023).

A number of recent studies published in the Journal of Innovation in Chemistry Learning (JIPK) further reinforce the importance of laboratory management in supporting effective chemistry learning. The first study highlights that structured laboratory management, particularly in planning and organizing practical activities, significantly improves students' engagement and science process skills (Nainggolan et al., 2019). The second study emphasizes that administrative systems such as inventory control, documentation of chemical usage, and scheduling contribute to the efficiency and continuity of laboratory utilization (W. D.

Siregar & Simatupang, 2020). Meanwhile, the third study focuses on laboratory spatial arrangement, showing that proper layout design, including the arrangement of equipment, ventilation, and safety access, plays a crucial role in supporting both learning effectiveness and safety (Sianturi & Panggabean, 2019). In addition, the fourth study examines the implementation of occupational health and safety (OHS) in school laboratories and finds that compliance with safety standards, including the use of personal protective equipment and hazard communication, increases students' safety awareness during experiments (Rizki & Syuhada, 2020). The fifth study highlights that laboratory management policies at the institutional level are essential in ensuring the sustainability and standardization of laboratory practices (Wardani et al., 2022).

These findings are further supported by recent international studies. A study by (Wang et al., 2025), emphasizes that effective laboratory management must integrate hazard identification, risk assessment, safety training, and strict policy implementation to minimize accidents and ensure sustainable laboratory operations (encing chemical). The study also highlights the importance of institutional roles in establishing comprehensive safety systems, including chemical storage management, equipment maintenance, and waste handling, which are fundamental components of occupational health and safety (OHS) in laboratories. Similarly (Siswanto et al., 2025), explain that laboratory management in educational settings involves systematic planning, organizing, implementation, and evaluation, supported by clear administrative systems and strong coordination among stakeholders to achieve effective learning outcomes (Siswanto et al., 2025). These studies confirm that laboratory effectiveness is strongly influenced by the integration of management, administration, safety practices, and institutional policies.

However, although these studies provide valuable insights, they tend to examine laboratory management,

administration, spatial organization, and OHS implementation separately. There is still a lack of comprehensive studies that integrate these aspects into a unified framework. This fragmentation limits a holistic understanding of how laboratory systems function as an interconnected entity in supporting chemistry learning.

Furthermore, previous studies often report various limitations in laboratory conditions, such as inadequate safety facilities, lack of laboratory personnel, suboptimal spatial design, and weak administrative systems, which hinder the effectiveness of laboratory utilization (Siswanto et al., 2025). In contrast, the findings of the present study indicate that the chemistry laboratory under investigation has generally met the essential standards of laboratory management, including adequate infrastructure, organized administration, proper spatial arrangement, and the implementation of safety procedures.

Therefore, this study differentiates itself by positioning laboratory management, administrative systems, spatial arrangement, and OHS implementation as interrelated components within a single integrated system, while also demonstrating that a well-managed laboratory with adequate facilities can achieve better effectiveness compared to previously reported conditions. This approach provides a more comprehensive and systemic analysis of educational laboratory effectiveness and contributes to strengthening the theoretical and practical understanding of integrated laboratory management in chemistry education.

LITERATURE REVIEW

Learning is a conscious process aimed at developing logical, critical, and creative thinking skills. In chemistry education, laboratory activities play a central role in achieving these objectives, as they provide direct experiences that bridge abstract concepts with real phenomena. While previous studies have highlighted the contribution of real and virtual laboratories

in improving students' learning outcomes, creativity, and conceptual understanding (S. R. Siregar et al., 2019).

The effectiveness of these learning approaches is fundamentally dependent on how the laboratory itself is managed. Laboratory work not only develops scientific process skills, learning interest, and critical thinking, but also requires proper management systems, including the organization of tools and materials, workspace arrangement, administrative control, and the implementation of occupational health and safety (OHS/K3) procedures (Rizki & Syuhada, 2020). Therefore, beyond instructional media and innovation, laboratory management becomes a key determinant of the quality, safety, and sustainability of chemistry learning.

A number of recent studies published in the *Journal of Innovation in Chemistry Learning (JIPK)* further reinforce the importance of laboratory management in supporting effective chemistry learning. The first study highlights that structured laboratory management, particularly in planning and organizing practical activities, significantly improves students' engagement and science process skills (Nainggolan et al., 2019). The second study emphasizes that administrative systems such as inventory control, documentation of chemical usage, and scheduling contribute to the efficiency and continuity of laboratory utilization (Siregar & Simatupang, 2020). Meanwhile, the third study focuses on laboratory spatial arrangement, showing that proper layout design, including the arrangement of equipment, ventilation, and safety access, plays a crucial role in supporting both learning effectiveness and safety (Sianturi & Panggabean, 2019). In addition, the fourth study examines the implementation of occupational health and safety (OHS) in school laboratories and finds that compliance with safety standards, including the use of personal protective equipment and hazard communication,

increases students' safety awareness during experiments (Rizki & Syuhada, 2020). The fifth study highlights that laboratory management policies at the institutional level are essential in ensuring the sustainability and standardization of laboratory practices (Wardani et al., 2022).

These findings are further strengthened by recent international studies. (Wang et al., 2025) emphasize that effective laboratory management must integrate hazard identification, risk assessment, safety training, and strict policy implementation to minimize accidents and ensure sustainable laboratory operations. This study also underlines the importance of institutional roles in establishing comprehensive safety systems, including chemical storage management, equipment maintenance, and waste handling as core components of OHS. Similarly, (Siswanto et al., 2025) explain that laboratory management in educational settings involves systematic planning, organizing, implementation, and evaluation, supported by well-structured administrative systems and strong coordination among stakeholders to achieve optimal learning outcomes. These studies collectively confirm that laboratory effectiveness is not determined by a single factor, but by the integration of management systems, administrative processes, safety practices, and institutional policies.

However, despite providing valuable insights, previous studies tend to examine laboratory management, administration, spatial organization, and OHS implementation separately. This fragmented approach limits a comprehensive understanding of how these components interact as an integrated system in supporting effective chemistry learning. Moreover, several studies report persistent challenges such as inadequate safety facilities, limited laboratory personnel, suboptimal spatial design, and weak administrative systems, which hinder laboratory effectiveness (Siswanto et al., 2025).

In contrast, the findings of the present study indicate that the chemistry laboratory under investigation has generally met the essential standards of laboratory management, including adequate infrastructure, organized administrative systems, proper spatial arrangement, and the implementation of OHS procedures. Therefore, this study differentiates itself by positioning laboratory management, administrative systems, spatial arrangement, and OHS implementation as interrelated components within a single integrated framework. This integrated perspective not only provides a more comprehensive and systemic analysis of educational laboratory effectiveness but also demonstrates that well-managed laboratories with adequate facilities can achieve better outcomes compared to previously reported conditions, thereby strengthening both theoretical and practical understanding of integrated laboratory management in chemistry education.

METHODS

This research was conducted at Sultan Iskandar Muda Private High School in Medan. The research method used was qualitative research, with descriptive qualitative data analysis. Qualitative descriptive research aims to explain in detail and provide answers to problems as clearly and as fully as possible (Rahmadhani et al., 2022).

Research Design

This study employed a descriptive qualitative research design, which aims to systematically describe and evaluate the actual conditions of chemistry laboratory management without testing hypotheses. This approach is appropriate for exploring real-world phenomena in depth and providing a comprehensive understanding of laboratory practices as they naturally occur (Rahmadhani et al., 2022). The study focuses on evaluating existing conditions rather than establishing causal relationships, thereby

emphasizing interpretative analysis of observed data.

Research Setting and Participants

The research was conducted at Sultan Iskandar Muda Private Senior High School in Medan. The participants were selected using purposive sampling, involving key informants who are directly engaged in laboratory management, namely the head of the laboratory and chemistry teachers. These participants were chosen due to their significant roles and responsibilities in organizing, implementing, and supervising laboratory activities.

Research Focus

This study focused on several main aspects of chemistry laboratory management, including:

- (1) laboratory organizational structure,
- (2) laboratory layout and spatial arrangement,
- (3) administrative systems,
- (4) management of equipment and chemical materials,
- (5) implementation of occupational health and safety (OHS), and
- (6) laboratory waste management practices.

These aspects were analyzed to determine the level of conformity between actual practices and established laboratory management standards.

Data Collection Techniques

Data were collected using three primary techniques:

1. **Observation**
Direct observations were conducted to examine the physical condition of the laboratory, including layout, equipment arrangement, safety facilities, and waste handling systems.
2. **Interviews**
Semi-structured interviews were carried out with the head of the laboratory and chemistry teachers to obtain in-depth information regarding laboratory management practices, administrative procedures, and operational systems.

3. Documentation

Documentation techniques were used to collect supporting data such as inventory records, laboratory organizational structures, and facility documentation to strengthen the validity of the findings.

Research Procedure

The research was conducted through several systematic stages: (1) preliminary identification of laboratory conditions, (2) observation of laboratory management practices, (3) data collection through interviews and documentation, (4) classification and organization of data based on research focus, and (5) comparison of findings with standard laboratory management criteria to evaluate their level of compliance.

Data Analysis Technique

Data analysis was performed using descriptive qualitative analysis, consisting of three main steps:

1. **Data Reduction:** Selecting, simplifying, and focusing relevant data obtained from observations, interviews, and documentation.
2. **Data Display:** Organizing data in a systematic and descriptive form to facilitate interpretation.
3. **Conclusion Drawing:** Interpreting the data to generate meaningful conclusions regarding the effectiveness of laboratory management.

This analysis process follows an interactive model, where data collection and analysis occur simultaneously to ensure the accuracy and depth of interpretation.

RESULT AND DISCUSSION

Organizational Structure

Based on the results of observations and interviews, the laboratory's organizational structure consists of the principal, vice principal, laboratory

coordinator, laboratory supervisor, and laboratory assistant. The findings from observations conducted at SMA Swasta Sultan Iskandar Muda Medan indicate that the laboratory's organizational structure has been well established and functions effectively. The structure includes several key components that play vital roles in laboratory management, such as the principal, laboratory coordinator, head of the chemistry laboratory, and chemistry teachers. The head of the chemistry laboratory performs their duties diligently, ensuring that all laboratory activities are carried out efficiently, systematically, and in accordance with the applicable procedures and safety standards.

A clear laboratory organizational structure demonstrates a focused management system and supports effective laboratory management. The specific division of roles and responsibilities enables each member of the organization to perform optimally while fostering strong collaboration in achieving common goals. These findings align with research by (Elseria, 2016), which states that successful laboratory management is heavily influenced by a clear organizational structure and coordination between members. With an effectively functioning structure, laboratory activities can be conducted in an organized, safe manner, and in accordance with established operational standards.

Laboratory Management and Layout

Laboratories are places where experiments and investigations are conducted and serve as essential support for science learning. Sultan Iskandar Muda Private High School, Medan, has three laboratories: chemistry, biology, and computer science. This research focused on the chemistry laboratory. Observations indicate that the laboratory management system at Sultan Iskandar Muda Private High School, Medan, is well-functioning. The organizational system involves various elements, from the principal to the students, and each functions effectively. The school also provides support for laboratory development, including the procurement of quality equipment.

In terms of equipment planning and management, all laboratory equipment is well-prepared before the activity begins and neatly stored in a dedicated cabinet. Chemical management is also systematically carried out through periodic inspections every six months to ensure the condition of the materials and plan for future procurement needs.

The chemistry laboratory layout meets standards in terms of ventilation, lighting, and space arrangement, although it is not yet equipped with a preparation room and fume hood. The laboratory is neatly arranged, with equipment and materials stored in closed glass cabinets, well-ventilated, and equipped with supporting facilities such as a rest area, prayer area, air-conditioned room, and well-maintained sanitation facilities.

Furthermore, the laboratory is equipped with 12 ceramic-topped lab tables, each with four chairs, as shown in Figure 1 below. Overall, the laboratory's conditions support the safe, systematic, and efficient implementation of lab activities.



Figure 1. Layout of the chemistry laboratory

The existence of a laboratory as a science learning facility requires effective management to optimally support practical activities. Good laboratory management, as stated by (Susanti et al., 2021), is the process of utilizing resources effectively and efficiently to achieve goals optimally and sustainably. This is reflected in the structured and systematic laboratory management at Sultan Iskandar Muda Private High School, Medan. The school's support in procuring facilities demonstrates a commitment to improving the quality of learning. Furthermore, regular planning for

equipment use and chemical management reflects the application of sound management principles, particularly in the areas of planning and control.

Although the laboratory layout meets most standards, the lack of a preparation room and fume hood remains a deficiency that requires attention. According to (Kaban et al., 2024), the presence of these facilities plays a crucial role in minimizing the risk of accidents in the laboratory. Therefore, the provision of a preparation room and a dedicated ventilation system could be development steps worth considering in the future. Overall, the well-organized laboratory, supported by adequate facilities, and a well-functioning management system demonstrate that the laboratory meets the standards for a safe and effective chemistry learning facility.

Laboratory Administration

Laboratory administration plays a crucial role in supporting the smooth operation of practical activities. Based on the results of observations and interviews, the laboratory administration at SMA Swasta Sultan Iskandar Muda Medan is managed through a manual recording system conducted periodically each semester. This administrative process includes laboratory inventory management as well as the procurement of new equipment and materials. The inventory is carried out by the head of the laboratory and chemistry teachers by checking the availability and condition of instruments and chemicals, which are then reported to the school administration for follow-up. This process helps laboratory managers plan practical needs, prevent equipment loss or damage, and ensure the adequate availability of chemical materials every semester.

In terms of administration, the manual recording system indicates that laboratory management has not yet optimally utilized technology. According to (Habich & Beutel, 2024), digitizing laboratory administration can improve

efficiency, accuracy, and data integrity through integrated systems and process automation. Furthermore, digitalization also supports more modern, data- and technology-driven laboratory management, thereby accelerating work and reducing errors.

Laboratory Utility Units (Supporting Facilities)

Based on its function, the laboratory serves as an essential facility for teachers to deepen their conceptual understanding, develop innovative teaching methods, and enhance practical skills that support the teaching and learning process. Therefore, to ensure that laboratory activities run smoothly and effectively, proper supporting utilities are required. Sultan Iskandar Muda Private Senior High School is well-equipped with complete utilities, including water, electricity, ventilation, and lighting, all of which play an important role in facilitating the successful implementation of experiments and other laboratory-based learning activities, as illustrated in the following figure 2.



Figure 2. Water source utilized as a laboratory utility

The success of laboratory functions is greatly influenced by the availability of adequate facilities and infrastructure. Research presented by (Mustika & Hamidah, 2025), shows that facilities such as water, electricity, ventilation, and lighting play a significant role in supporting the effectiveness of practical activities. A recent systematic review also confirmed that the completeness of laboratory facilities directly contributes to improving the quality of

learning, practical skills, and student motivation.

Furthermore, utility aspects such as ventilation and lighting not only serve to support the smooth running of experimental activities but are also closely related to work safety in the laboratory. Recent research shows that a lack of basic facilities such as adequate ventilation and water flow can increase the risk of accidents and endanger the health of laboratory users (Aliyo & Edin, 2023). Therefore, the existence of complete utilities in the laboratory of Sultan Iskandar Muda Medan Private High School reflects conditions that comply with safety and comfort standards in practical-based learning. Thus, the completeness of laboratory utilities not only shows the quality of good facility management, but also becomes an important indicator in supporting the creation of effective, safe chemistry learning that is oriented towards the optimal development of students' scientific skills.

Storage of Equipment and Chemical Materials

Based on observations, the implementation of safety procedures in the laboratory is supported by well-organized chemical and equipment management. Storage facilities for tools and chemicals are systematically arranged in wooden cabinets with transparent glass doors, allowing for easy monitoring and ensuring safety. Damaged equipment is promptly replaced with new ones to maintain its suitability for use.

Although there is no fixed maintenance schedule, the condition of the laboratory equipment is deemed adequate and suitable for practical activities. Chemicals are stored in special cabinets separated by container type and material characteristics. The laboratory administration system is also well-functioning, with periodic records maintained every semester, including inventory of facilities and infrastructure, as

well as procurement of equipment and materials.



Figure 3. Cabinet for storing equipment and chemical materials

According to Figure 3, the management of laboratory equipment and materials is neatly organized and well-maintained. Various equipment such as volumetric flasks, test tube clamps, spatulas, thermometers, mortars and pestles, and Erlenmeyer flasks are stored in special cabinets. Additional equipment such as rubber bulbs, analytical balances, magnifying glasses, sample labels, droppers, universal indicators, and litmus paper are also neatly arranged in storage drawers. In addition, eight titration stands are systematically placed under the workbench.

Interview results indicated that the availability of equipment and chemicals in the laboratory was sufficient to support learning activities. Chemical stocks were adequate, with teachers routinely checking every six months. Chemicals were procured in quantities exceeding requirements to ensure adequate access for each laboratory group.

A well-established chemical storage system was implemented, with labeling and separation of materials based on concentration and hazard level. Concentrated chemicals such as HCl, H₂SO₄, chloroform, and NH₃ were stored in upper cabinets to keep them out of reach of students. Furthermore, each hazardous material was accompanied by a Material Safety Data Sheet (MSDS) containing information regarding the characteristics and risks of the material. Prior to the laboratory work, students were also provided with an

explanation of the materials used and their potential hazards.

Proper chemical management is a crucial part of implementing standard operating procedures (SOPs) to prevent laboratory accidents. Identifying the type and nature of chemicals is a crucial first step in ensuring safe and proper handling, as stated by (Tumanan et al., 2022). This demonstrates that chemical management in the laboratory adheres to sound occupational safety principles.

An organized storage system, including the separation of materials based on their nature and hazard level, and the use of secure storage cabinets, reflects effective laboratory management practices. This aligns with the view of (Manokhun & Thiamngoen, 2020), who stated that a good storage system supported by regular inventories is a key factor in efficient laboratory administration.

The availability of adequate quantities of chemicals and regular inspections demonstrate sound planning and control in laboratory management. Furthermore, providing MSDSs as a source of safety information is a crucial step in minimizing the risk of accidents. According to (Sultan et al., 2023), MSDSs contain important information regarding material characteristics, potential hazards, and safe handling procedures, making them essential in all laboratory activities.

However, the lack of a structured maintenance schedule may be a weakness that needs to be addressed. Scheduled periodic maintenance is essential for maintaining the long-term quality and safety of equipment. Therefore, developing a more systematic maintenance system is necessary to improve the overall effectiveness of laboratory management.

Overall, the management of equipment and materials, as well as the implementation of safety aspects in the laboratory, have been well-executed and

support safe, effective, and standard-compliant laboratory activities.

Laboratory Safety and Security

Based on observations, the chemistry laboratory at Sultan Iskandar Muda Private High School in Medan is equipped with adequate safety equipment. These safety facilities include a first aid kit stored in a cupboard, a portable fire extinguisher (APAR) available on each floor outside the laboratory, and the use of personal protective equipment (PPE) such as lab coats, masks, and gloves during laboratory activities. All safety equipment is regularly inspected to ensure its condition and validity period.

Furthermore, laboratory safety is implemented through the implementation of standard operating procedures (SOPs), including mandatory use of PPE, an understanding of equipment usage, and knowledge of chemical characteristics. Laboratory use is routinely evaluated at the end of each semester through meetings involving all laboratory administrators. Laboratory planning for the following academic year is also conducted twice a year.

Observations also indicate that the laboratory has complete and well-maintained supporting safety facilities, such as fire extinguishers and first aid kits, which are regularly inspected, as shown in Figure 4. The availability of first aid facilities and regular inspections of medical equipment demonstrate the laboratory's readiness to face emergencies. In addition, safety implementation is also supported by labeling of hazardous materials, provision of wound care equipment, and routine monitoring of tools and chemicals.



Figure 4. (a) Fire Extinguisher; (b) First Aid Kit

The availability of laboratory safety equipment is a crucial factor in minimizing the risk of workplace accidents. This aligns with the view of Suidiana et al. (2021), who stated that safety facilities play a crucial role in creating a safe laboratory environment. Furthermore, integrating education about chemical hazards into learning activities is also crucial for raising student awareness of Occupational Safety and Health (OHS) principles (De Oliveira et al., 2021).

The use of personal protective equipment (PPE) and the implementation of standard operating procedures (SOPs) demonstrate that the laboratory has implemented good safety standards. This is crucial considering that laboratories have the potential for high risks, such as exposure to hazardous chemicals, fires, and other workplace accidents. (Rahmantiyoko et al., 2019) emphasized that understanding work procedures and the use of protective equipment are key aspects in preventing laboratory accidents.

Furthermore, effective safety management encompasses not only the availability of equipment but also requires comprehensive risk management, including evaluation of spatial layout, ventilation, lighting, and hazardous waste management. This aligns with research by (Trasmini et al., 2021), emphasized the importance of a risk management system in maintaining safety and preventing environmental pollution. Regular training and evaluations are also crucial in improving the effectiveness of OHS implementation in laboratories (Taofik et al., 2023).

The availability of facilities such as fire extinguishers and first aid kits, which are regularly checked, demonstrates the laboratory's preparedness for emergencies. This reflects a commitment to creating a safe and risk-free learning environment. Overall, the implementation of a sound safety system, supported by adequate facilities and regular evaluations, demonstrates that the laboratory has met occupational safety principles and is

able to support learning activities safely and effectively.

Laboratory Activity Implementation

Based on observations and interviews, laboratory activities involve good coordination between science teachers, laboratory coordinators, and laboratory assistants. They are responsible for managing, maintaining, and maintaining the cleanliness of laboratory equipment, materials, and facilities. Practical activities are conducted routinely every week using a group system. Each class is divided into two large groups, Group X and Group Y, which alternate between odd and even weeks. Each group consists of six smaller teams of four to five students. During the practicums, students use a chemistry practicum guidebook as a reference for conducting experiments.

Students' practicum skills are assessed through conducting experiments and preparing practicum reports. Furthermore, practicums have been shown to help students understand abstract chemical concepts through hands-on experience in the laboratory.

The implementation of laboratory activities, which involves coordination between teachers, coordinators, and laboratory assistants, demonstrates a well-organized management system. This aligns with (Elseria, 2016), which states that collaboration between laboratory managers is crucial for supporting the success of practicum activities and maintaining the sustainability of laboratory facilities.

Practical activities play a crucial role in improving the quality of learning, particularly in developing students' scientific skills. Classroom learning tends to focus on cognitive aspects, while laboratory activities provide opportunities for students to develop practical skills and scientific processes. This is reinforced by (Kurniawan et al., 2019), who stated that hands-on experience through experiments can improve conceptual

understanding, scientific thinking skills, and problem-solving abilities.

The group assignment system for practicum implementation demonstrates effective management to ensure all students have equal opportunities to conduct experiments. Furthermore, the use of a practicum guidebook as a reference provides a clear structure for the implementation of activities, from the preparation stage to reporting. This aligns with the findings of (Yudha et al., 2023), who emphasized that practicum guides play a crucial role in helping students carry out laboratory activities systematically, independently, and with direction.

Overall, the implementation of structured laboratory activities supported by practical guidelines and a clear evaluation system shows that practical activities have been carried out effectively in supporting the achievement of student competencies.

Waste and Garbage Management

Based on observations and interviews, waste management at Sultan Iskandar Muda Private High School in Medan has been implemented quite well. The school provides special jerry cans to collect liquid waste from laboratory activities before disposal, preventing it from being directly discharged into the drainage system. Furthermore, separate bins are provided for plastic, paper, and organic waste within the school grounds.

Interviews indicate that waste management practices have begun to receive positive attention. Liquid waste is collected in special containers before disposal, while solid waste is separated into designated bins according to type. This system demonstrates efforts to separate waste based on its characteristics. Through this waste management system, the school also strives to instill environmental awareness in students and educators, thereby creating a clean and healthy learning environment, as shown in Figure 5.



Figure 5. (a) Trash Bin; (b) Waste Disposal Site

Laboratory waste management is a crucial aspect of preserving the environment and preventing negative impacts from practical activities. While common, the use of chemicals in waste treatment processes, such as coagulants and flocculants, is often uneconomical and has the potential to have long-term environmental impacts (Rohana et al., 2025). Therefore, a more effective and environmentally friendly waste management approach is needed.

Schools' efforts to provide dedicated containers for liquid waste and a solid waste sorting system demonstrate an awareness of the importance of proper waste management. However, when viewed from modern laboratory management standards, the systems implemented are still relatively rudimentary and require further development to be more structured and compliant with established operational standards.

Furthermore, although students have basic knowledge of waste management, their application in practice remains inconsistent. This highlights the need for the development and implementation of clear Standard Operating Procedures (SOPs) regarding waste sorting, labeling, and disposal. According (Sulistiyorini et al., 2022), emphasize that structured SOPs can help foster more disciplined and responsible behavior in waste management.

Furthermore, the weak implementation of waste management and safety policies in educational laboratories demonstrates the need to strengthen internal regulations and increase oversight of safety standards (Lestari et al., 2016). Therefore,

waste management in laboratories serves not only to maintain cleanliness but also as part of efforts to create a sustainable and environmentally conscious learning environment.

CONCLUSION

This study reveals that the chemistry laboratory management at Sultan Iskandar Muda Private Senior High School Medan has generally fulfilled the essential standards of laboratory management through the integration of organizational structure, laboratory layout, administrative systems, equipment and chemical management, occupational health and safety (OHS), implementation of laboratory activities, and waste management practices. The main finding of this study indicates that well-organized and integrated laboratory management contributes significantly to the effectiveness, safety, and sustainability of chemistry learning activities.

The study also found that proper management of laboratory facilities and safety systems supports students' practical skills development, improves the implementation of experimental activities, and creates a safer and more conducive learning environment. In addition, the availability of adequate facilities, systematic chemical storage, implementation of OHS procedures, and structured laboratory coordination demonstrate that integrated laboratory management can optimize the function of laboratories as an important component of science education.

However, several aspects still require further improvement, particularly the digitalization of laboratory administration systems, the development of a more structured and environmentally sustainable waste management system, and the provision of additional supporting facilities such as a preparation room and fume hood. These improvements are important to strengthen laboratory efficiency, safety standards, and long-term sustainability.

The findings of this research contribute to the development of science and educational technology by emphasizing the importance of integrated laboratory management systems in supporting modern chemistry education. Furthermore, this study can serve as a reference for schools, laboratory managers, and policymakers in developing more effective, technology-based, and sustainable laboratory management models. Future research is recommended to explore the integration of digital technology, environmental management systems, and advanced safety practices in educational laboratories to further improve the quality of laboratory-based science learning.

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