

**Received** : 04 November 2025**Revised** : 10 February 2026**Accepted** : 31 May 2026**Published** : 31 May 2026**Page** : 113 – 125

Analysis of Chemistry Laboratory Management at SMA Negeri 2 Percut Sei Tuan

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Abstract : This study analyzes the management of the chemistry laboratory at SMA Negeri 2 Percut Sei Tuan by integrating aspects of facilities, administration, organization, safety, and waste management. A descriptive qualitative approach was employed using observation, interviews, and documentation to obtain a comprehensive understanding of laboratory practices. The findings indicate that the laboratory has met basic operational standards and is classified as a Type I laboratory based on PERMENPAN No. 3 of 2010. However, several gaps were identified between facility availability and effective management. These include non-functional infrastructure, incomplete administrative records such as the absence of chemical labeling and stock cards, limited safety facilities (e.g., fire extinguishers and eye wash stations), and inadequate waste management practices. The study highlights that laboratory quality is determined not only by physical resources but also by the integration of management systems, safety implementation, and sustainability practices. The main contribution of this research lies in providing a comprehensive framework for evaluating school laboratory management holistically. Practically, the findings suggest the need for digital inventory systems, improved safety facilities, structured waste management, and regular occupational safety training. This study offers important implications for developing effective, safe, and sustainable chemistry laboratory management in secondary education.

Keywords: administration; laboratory management; safety; waste management; secondary education.

INTRODUCTION

Chemistry laboratories play a crucial role in science education as they provide opportunities for students to engage in experimental activities, develop practical skills, and foster scientific attitudes such as critical thinking, problem-solving, and awareness of laboratory safety. Laboratory-based learning enables students to bridge the gap between theory and practice, making

abstract chemical concepts more meaningful and applicable in real-life contexts (Evana et al., 2021).

Therefore, the implementation of effective laboratory activities is essential in achieving quality chemistry learning. However, the success of laboratory-based learning is not solely determined by the availability of facilities and equipment. The effectiveness of laboratory activities is strongly influenced by how laboratories are

managed, including aspects of planning, implementation, supervision, and evaluation (Setiawan et al., 2020).

Poor laboratory management may result in inefficient use of resources, limited student engagement, and increased safety risks. Thus, proper laboratory management is a fundamental requirement in supporting effective and safe chemistry learning.

In the context of school education, many laboratories have not been managed optimally, even though facilities are relatively available. This condition causes laboratory activities to be carried out only as routine procedures without meaningful learning experiences for students. In addition, the absence of structured planning and evaluation often results in practicum activities that are not aligned with learning objectives. As a result, laboratory-based learning has not been able to fully support the development of students' scientific skills and understanding (Kurniadewi et al., 2021).

Findings from previous studies also indicate that low student motivation and the use of less varied learning models contribute to suboptimal learning outcomes in chemistry learning. Students tend to memorize concepts rather than understand them, which affects their engagement and academic achievement. The application of active learning models such as Problem Based Learning (PBL) and Discovery Learning (DL) has been shown to significantly improve student motivation and learning outcomes, as well as demonstrate a strong relationship between motivation and achievement (Tua et al., 2023).

Furthermore, laboratory-integrated learning models have also been proven to enhance learning effectiveness. The integration of Discovery Learning with the Learning Cycle 5E supported by virtual laboratories, allows students to construct knowledge actively through exploration and experimentation, leading to better conceptual understanding (Siallagan et al., 2024)

In addition, the development of critical thinking skills is closely related to the use of innovative learning resources. Project-based learning approaches in chemistry have been shown to improve students' critical thinking abilities and engagement in learning activities (Simalango & Situmorang, 2024).

Moreover, students' initial abilities and generic science skills also influence the effectiveness of laboratory-based learning. Students with better basic science skills tend to perform more effectively in practicum activities and demonstrate higher levels of understanding in chemistry concepts (Pardosi & Situmorang, 2024).

Despite these findings, previous studies tend to focus more on learning models, student motivation, or individual skills, rather than examining laboratory management as a comprehensive system. As a result, the integration between laboratory management and instructional strategies has not been fully explored.

Therefore, this study aims to address this gap by providing a comprehensive analysis of chemistry laboratory management that integrates technical, administrative, pedagogical, and safety aspects.

The novelty of this study lies in its integrative approach, which not only examines individual components of laboratory management but also analyzes the relationships between laboratory management and learning effectiveness in chemistry education.

LITERATURE REVIEW

Laboratory Observation

Laboratory observation is a structured process aimed at evaluating and overseeing the operation, use, and status of educational labs. This activity serves not only as a form of oversight but also as a method of assessment to refine the management system, strengthen safety measures, and ensure successful learning through experiments. In contrast to survey methods, direct observations in the

field offer a more factual and confirmable representation of real laboratory environments, as self-reporting techniques can lead to inflated perceptions of the quality of implementation (Lase et al., 2025; N & Taslima, 2022).

The success of chemistry learning in a laboratory setting is influenced by the quality of the practicum guide employed. A modern, project-based practicum guide has demonstrated a much greater positive impact on learning than traditional guides, especially concerning clarity of procedures, student productivity, and fostering scientific character (Nainggolan et al., 2019).

Additionally, the creation of practicum modules that incorporate project-based learning methodologies can enhance both learning outcomes and student involvement in chemical experiments during senior high school. These results underscore that effective observation in laboratory settings is inseparable from the caliber of instructional resources and guides that facilitate practical experiences in secondary chemistry classrooms (Nasution & Jahro, 2023).

Laboratory Management

Laboratory administration includes the activities of planning, organizing, executing, and overseeing to guarantee that laboratory functions are conducted effectively, efficiently, and safely. It involves planning, management, maintenance, safety protocols, and funding as interconnected components (Agily et al., 2022).

Effective management allows laboratories to cultivate scientific competencies, critical analysis skills, and a scientific mindset among learners (Ramdan et al., 2019).

Nonetheless, research findings consistently highlight the existence of gaps in implementation: numerous secondary educational institutions face challenges regarding administrative management and

ineffective facility usage, even with sufficient physical resources (Asmarany et al., 2024).

A study involving 99 chemistry educators indicated that the average level of managerial skills was only 16.26%, with the organization aspect being the most overlooked at merely 2.53% (Sartika & Timan, 2025).

Laboratory Inventory and Administration

Laboratory inventory is utilized to document, oversee, and manage all resources necessary for practical operations, financial planning, and upkeep of facilities. Automated systems for inventory enhance precision greatly when compared to traditional manual documentation, however, many secondary schools in Indonesia continue to depend on manual methods that are vulnerable to inaccuracies. Important safety indicators such as chemical stock cards, condition logs, and standard labeling are often missing from practices at the school level (Aliyo & Edin, 2023; Setiawan et al., 2020).

The sufficiency of laboratory resources and stock is directly related to the practicality of hands-on learning. Research regarding the use of virtual laboratories in high school education indicates that a significant reason for adopting virtual solutions is the shortage of actual chemical materials and tools in traditional laboratories (Pardosi & Situmorang, 2024).

This result suggests that shortcomings in inventory are not just an organizational issue, but they limit the variety of experiments that students can conduct and diminish the quality of practical chemistry instruction. Effective inventory oversight is thus essential to uphold the complete range of the chemistry practical syllabus in secondary education.

Laboratory Organization and Human Resources

Organized management within an institution characterized by reciprocal communication among educators, lab technicians, and learners has demonstrated the

ability to enhance success in practical sessions (Silvia & Aryanti, 2022).

Collaboration among school administration, subject matter instructors, and laboratory personnel enhances the effectiveness of budget management and the acquisition of equipment. However, challenges with human resources continue to be a systemic hindrance: managerial skill assessments reveal alarmingly low scores in aspects of planning, organizing, controlling, and evaluation, suggesting that, despite having adequate facilities, laboratory effectiveness cannot be guaranteed without sufficient organizational capability (Nufrika, 2024; Sartika & Timan, 2025).

Occupational Health and Safety (K3)

K3 implementation involves the arrangement of safety facilities, the establishment of safe work protocols, and fostering a safety-oriented culture. Schools that put Standard Operating Procedures into practice prior to hands-on work witness a decrease of 25% in laboratory incidents, while fully equipped safety facilities are linked to a reduction of 30% in accident occurrences (April et al., 2025; Ernada, 2023).

Regular safety training enhances readiness for emergencies. Nevertheless, the safety protocols in numerous secondary school laboratories in Indonesia are often not applied consistently, primarily due to a lack of adequate facilities and insufficient training. This indicates that solely relying on compliance-based methods is not enough without backing from institutions and a supportive organizational culture (Aliyo & Edin, 2023).

Laboratory Waste Management

A majority of high school laboratories in Indonesia do not have sufficient waste management systems because of inadequate facilities, lack of technical expertise, and the absence of internal regulations (Sulistiyanti, 2018).

Effective waste management should involve the processes of sorting, collecting, temporarily storing, treating, and finally disposing of waste according to its characteristics. Utilizing the principles of green chemistry, which emphasize reduction, reuse, recycling, and rethinking (4R), provides a viable approach for reducing waste generated in laboratories. Nevertheless, the literature on sustainability primarily focuses on higher education environments, resulting in a lack of exploration regarding its implementation in secondary schools (Pramestyawati, 2019; Taufik, Seveline, et al., 2018).

Research Gap

An important review of the existing literature highlights a notable shortcoming: prior research has focused on aspects of laboratory management such as facilities, administration, safety, human resources, and sustainability individually instead of viewing them as part of a cohesive system (N & Taslima, 2022; Sartika et al., 2025).

To date, there has not been a single study at the secondary school level in Indonesia that merges all these elements into a cohesive analytical framework applicable to one institution. Consequently, the research gap is evident in the absence of thorough and integrative studies that evaluate chemistry laboratory management in a holistic manner within secondary schools. This investigation seeks to fill that gap by combining technical (spatial design and facilities), administrative (inventory management and record-keeping), organizational (structure and personnel), safety (occupational health and personal protective equipment), and environmental (waste disposal) aspects into a thorough observational study at SMAN 2 Percut Sei Tuan, resulting in evidence-based suggestions relevant to similar secondary school laboratories across Indonesia (Agily et al 2022; Taufik, Saputri, et al., 2018).

METHODS

Research Design

This study employed a descriptive qualitative design with an observational approach to analyze the management of the chemistry laboratory at SMA Negeri 2 Percut Sei Tuan. The research focused on understanding laboratory management practices in terms of facilities and infrastructure, administrative systems, safety procedures, and human resources. This study did not involve statistical calculations or quantitative analysis, as it aimed to provide an in-depth descriptive understanding of the observed phenomena.

Research Site and Subjects

The research was conducted at the chemistry laboratory of SMA Negeri 2 Percut Sei Tuan. The subjects included the head of the laboratory, chemistry teachers, and students who actively use the laboratory. The objects of the study comprised laboratory facilities, equipment, materials, administrative documents, and safety systems.

Data Collection Techniques

Data were collected using three techniques:

1. Observation, to examine laboratory conditions, layout, equipment availability, and safety facilities.
2. Interviews conducted with the head of the laboratory, teachers, and students to obtain information about laboratory management practices.
3. Documentation study to review supporting documents such as inventory records, borrowing forms, standard operating procedures (SOP), and relevant regulations.

Research Instruments

The instruments used included observation sheets, interview guidelines, and documentation checklists to ensure

systematic data collection aligned with the research objectives.

Data Analysis

Data analysis was conducted qualitatively through the following stages:

1. Data reduction; organizing, selecting, and summarizing data based on key research aspects.
2. Data display; presenting data in descriptive narratives, tables, and figures to illustrate findings clearly.
3. Conclusion drawing and verification; interpreting the data in relation to relevant theories, literature, and laboratory management standards.

Data Validity

To ensure the validity and credibility of the data, this study applied triangulation techniques, including:

1. Source triangulation (comparing information from laboratory staff, teachers, and students).
2. Method triangulation (comparing results from observation, interviews, and documentation).

In addition, member checking was conducted by confirming interview results with respondents, and prolonged observation was used to obtain consistent and reliable data.

Research Position and Assumptions

The researcher acted as a non-participant observer to maintain objectivity. This study did not use formal hypotheses; however, it was guided by initial assumptions that laboratory management should meet established educational and safety standards. These assumptions served only as a reference framework and did not influence data interpretation.

RESULT AND DISCUSSION

Laboratory Layout

Observations show that the chemistry laboratory at SMA Negeri 2 Percut Sei Tuan is classified as a Type I laboratory based on PERMENPAN No. 3 of 2010. The laboratory has a rectangular layout ($\pm 8 \times 10$ m) with a capacity of around 30 students. The room includes an entrance and exit door, storage room, and equipment cabinets. However, several facilities are not fully functional. Of the available sinks, only some can be used properly, while others are



Figure 1. Layout of Laboratory



Figure 2. Laboratory table sink

The existing layout indicates that the laboratory has met basic spatial requirements. However, the functionality of facilities is more critical than mere availability. Effective laboratory design should integrate workflow efficiency and safety zoning. The partially functioning sinks indicate weak maintenance management, which may disrupt practicum activities and hygiene standards (Sihotang et al., 2024).

Furthermore, ergonomic aspects have not been optimally considered. Emphasize that laboratory design should support user

comfort and safety. The current layout still needs improvement to enhance supervision, mobility, and emergency evacuation access. Thus, the laboratory requires not only facility provision but also optimization through maintenance and layout redesign (Wijaya et al., 2020).

Laboratory Administration

The results show that the chemistry laboratory at SMA Negeri 2 Percut Sei Tuan has implemented basic administrative management. This is indicated by the availability of equipment inventory records. Borrowing forms, and the physical arrangement of tools based on type. Inventory data and equipment records are still managed manually using written documents. In addition, the laboratory provides borrowing forms that include information such as practicum title, borrowing date, and return date.

Figure 3. Laboratory inventory data

No	Nama Barang	Jumlah	Status
1	LARF 1 METYLENE BLUE	1	UTER
2	METILTI FIN SUD	1	UTER
3	GLAS	1	UTER
4	WASHER	1	UTER
5	GLASSER SUP	1	UTER
6	ADH ADAS	15	PASANG
7	KANING PISAN KABET	1	UTER
8	ZITA MAGNESIUM	1	UTER
9	GLASSER PISAN	1	UTER
10	KUBITAS WANGUNIN SE	1	UTER
11	RELASION TOTAL PROSEDUR GOSOK	1	UTER
12	STATA BANGUNAN ALAS	1	UTER
13	GLASSER PISAN	1	UTER
14	GLASSER PISAN	1	UTER
15	GLASSER PISAN	1	UTER
16	GLASSER PISAN	1	UTER
17	GLASSER PISAN	1	UTER
18	GLASSER PISAN	1	UTER
19	GLASSER PISAN	1	UTER
20	GLASSER PISAN	1	UTER
21	GLASSER PISAN	1	UTER
22	GLASSER PISAN	1	UTER
23	GLASSER PISAN	1	UTER
24	GLASSER PISAN	1	UTER
25	GLASSER PISAN	1	UTER
26	GLASSER PISAN	1	UTER
27	GLASSER PISAN	1	UTER
28	GLASSER PISAN	1	UTER
29	GLASSER PISAN	1	UTER
30	GLASSER PISAN	1	UTER
31	GLASSER PISAN	1	UTER
32	GLASSER PISAN	1	UTER
33	GLASSER PISAN	1	UTER
34	GLASSER PISAN	1	UTER
35	GLASSER PISAN	1	UTER
36	GLASSER PISAN	1	UTER
37	GLASSER PISAN	1	UTER
38	GLASSER PISAN	1	UTER
39	GLASSER PISAN	1	UTER
40	GLASSER PISAN	1	UTER
41	GLASSER PISAN	1	UTER
42	GLASSER PISAN	1	UTER
43	GLASSER PISAN	1	UTER
44	GLASSER PISAN	1	UTER
45	GLASSER PISAN	1	UTER
46	GLASSER PISAN	1	UTER
47	GLASSER PISAN	1	UTER
48	GLASSER PISAN	1	UTER
49	GLASSER PISAN	1	UTER
50	GLASSER PISAN	1	UTER

Figure 4. Equipment Loan Form

Equipment is arranged in cabinets according to categories, such as glassware and general tools, to facilitate access during practicum activities. identified. Inventory records do not include detailed information about equipment. However, several limitations were identified. Inventory records do not include detailed information about

equipment condition, frequency of use, or procurement year. Furthermore, the management of chemical and non-chemical materials is incomplete, as many materials do not have labels or stock cards. Inventory checks are also conducted infrequently, approximately once every six months.



Figure 5. Cabinet for Chemical Glassware Storage



Figure 6. Material Storage Room

The existence of inventory records and borrowing systems indicates that administrative management has been initiated in accordance with basic laboratory standards. However, the reliance on manual systems limits efficiency, accuracy, and accessibility of data. Digital inventory systems significantly improve asset tracking, minimize loss, and support more effective planning of laboratory needs (Setiawan et al., 2020).

The absence of detailed equipment records weakens maintenance management. Without information on equipment condition and usage history, it is difficult to prioritize repairs or replacement. This condition may reduce the effectiveness of practicum activities and increase operational risks.

More critically, incomplete labeling and the absence of chemical stock cards represent a serious safety issue. Proper

labeling is essential to identify chemical properties, hazards, and expiration status. Without this information, the risk of misidentification, improper handling, and laboratory accidents increases. This finding indicates that the laboratory has not fully complied with standard laboratory management practices, which require systematic documentation and classification of materials.

In addition, infrequent inventory monitoring reduces control over laboratory assets. Regular inspection is necessary to ensure that all equipment and materials are in safe and usable condition.

Therefore, improving laboratory administration requires a systematic approach, including the implementation of digital inventory systems, standardized labeling of chemicals, regular stock monitoring, and detailed recording of equipment condition. These improvements are essential not only to enhance administrative efficiency but also to support laboratory safety and sustainability (Nurfajriani et al., 2024).

Laboratory Organization

The organizational structure of the chemistry laboratory at SMA Negeri 2 Percut Sei Tuan consists of the principal, vice principal for curriculum, vice principal for facilities, laboratory head, and chemistry teachers. These personnel are responsible for managing laboratory activities, including planning and implementing practicum sessions.

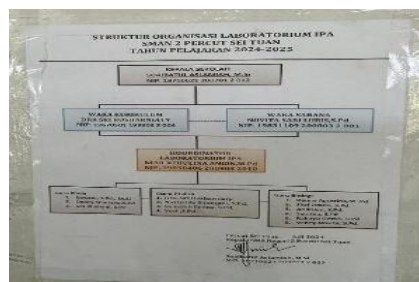


Figure 7. Laboratory Organizational Structure

However, the structure remains relatively simple and does not include

dedicated laboratory technicians or assistants. The distribution of roles is not formally documented in detailed job descriptions, and coordination mechanisms such as routine meetings or reporting systems are not yet systematically implemented.

The presence of a basic organizational structure indicates that laboratory management has been institutionally recognized. However, the absence of clearly defined roles and specialized personnel limits the effectiveness of management practices. well-structured laboratory organization with clear task division improves coordination, efficiency, and the quality of practicum implementation (Silvia & Aryanti, 2022).

The lack of laboratory assistants increases the workload of teachers, who must handle both instructional and technical responsibilities. This dual role can reduce focus on teaching and limit proper laboratory maintenance. Furthermore, the absence of structured coordination such as routine meetings or reporting systems may lead to miscommunication and inefficiencies in laboratory operations.

From a management perspective, effective laboratory organization also requires formal planning and evaluation systems. Emphasizes that integration between school leadership and laboratory staff enhances resource management and program sustainability. Without a clear organizational framework, decision-making related to procurement, maintenance, and safety may become less systematic (Nufrika, 2024).

Therefore, strengthening laboratory organization is essential. This can be achieved by establishing a dedicated laboratory management team, defining clear job descriptions, involving laboratory assistants, and implementing regular coordination and reporting systems. These improvements will enhance efficiency, accountability, and overall laboratory performance, ultimately supporting better chemistry learning outcomes.

Laboratory Safety

The results indicate that basic laboratory safety practices have been implemented at SMA Negeri 2 Percut Sei Tuan. Students are required to use personal protective equipment (PPE), including lab coats, gloves, masks, and safety goggles before conducting practicum activities. A first aid kit is also available in the laboratory to handle minor accidents.



Figure 8. First Aid Kit

In addition, the laboratory has adequate natural ventilation, supported by multiple windows that are opened during practicum activities. This condition helps reduce the accumulation of chemical vapors and supports a safer working environment.



Figure 9. Ventilation in the Laboratory

However, several critical safety facilities are not yet available. The laboratory does not have a fire extinguisher (APAR), and an eye wash station is also absent. These limitations indicate that emergency response facilities are still incomplete.

The implementation of PPE usage reflects an initial awareness of safety culture among students and teachers. However, laboratory safety management should not only rely on individual behavior but also on the availability of complete safety facilities. Effective occupational health and safety (OHS) in laboratories requires the integration

of safety equipment, standard procedures, and user discipline (Desy, 2020).

The absence of fire extinguishers and eye wash stations represents a significant gap in meeting laboratory safety standards. These facilities are essential for handling emergencies such as fires and chemical splashes. Without them, the risk of serious injury or damage increases, especially in chemistry laboratories where hazardous substances are frequently used.

Although ventilation conditions are adequate, safety management must also include preventive and responsive measures. Highlights that safety training plays an important role in improving users' preparedness in emergency situations. In the current condition, there is no indication of regular safety training or emergency simulations, which limits the effectiveness of existing safety practices (Kurniadewi et al., 2021).

Furthermore, safety implementation should be supported by consistent enforcement of Standard Operating Procedures (SOPs). The existence of SOPs alone is insufficient if not accompanied by monitoring and habituation. A comprehensive safety system requires continuous supervision, clear signage, and periodic evaluation.

Therefore, improving laboratory safety requires a systematic approach, including the provision of essential safety facilities such as fire extinguishers and eye wash stations, regular safety training for students and teachers, and stricter implementation of SOPs. These efforts are crucial to creating a safe, controlled, and sustainable laboratory environment that supports effective chemistry learning.

Preparation Before Practicum

The results show that students at SMA Negeri 2 Percut Sei Tuan are required to prepare personal protective equipment (PPE) before conducting laboratory activities. The school provides lab coats, while students

bring additional PPE such as gloves, masks, and safety goggles. This requirement is consistently implemented prior to practicum sessions.

However, the preparation process is limited to PPE usage. There is no structured safety briefing, checklist verification, or formal pre-laboratory orientation conducted before practicum activities begin.

The use of PPE indicates that basic safety awareness has been introduced in laboratory practices. PPE serves as the first line of protection against chemical exposure, physical hazards, and minor accidents. However, effective laboratory preparation should go beyond equipment usage.

A comprehensive pre-practicum procedure should include safety briefings, hazard identification, and clear instructions regarding experimental procedures. Without these steps, students may not fully understand potential risks, even if they are equipped with PPE. This condition reduces the effectiveness of safety implementation and increases the likelihood of procedural errors.

In addition, the absence of a standardized preparation checklist limits the ability to ensure that all students are fully ready before entering the laboratory. Supervision also plays an important role in reinforcing safety compliance and preventing unsafe behavior.

Therefore, pre-practicum preparation needs to be strengthened through structured safety briefings, implementation of readiness checklists, and active supervision by teachers or laboratory staff. These improvements will enhance safety awareness, reduce risks, and support more effective and disciplined laboratory activities.

Waste Management

The findings indicate that laboratory waste management at SMA Negeri 2 Percut Sei Tuan has not been implemented in accordance with standard procedures. Most chemical residues generated during practicum

activities are disposed of directly into the sink without prior separation, treatment, or neutralization. This practice is based on the assumption that the chemicals used are low hazard.

In addition, there is no specific system for waste segregation, labeling, or temporary storage. The laboratory also does not have written procedures or facilities that support proper waste management practices.

The direct disposal of chemical waste into sinks reflects a significant gap between existing practices and standard laboratory management principles. Laboratory waste management should include several stages, namely segregation, collection, treatment, and controlled disposal based on waste characteristics. The absence of these stages increases the risk of environmental pollution and potential damage to plumbing systems (Pramestyawati, 2019).

The lack of waste classification and labeling also indicates limited awareness of chemical hazards. Even chemicals considered low risk can accumulate and cause negative environmental impacts if disposed of continuously without treatment. This finding is consistent, who reported that many school laboratories in Indonesia still lack proper waste management systems due to limited facilities and technical knowledge (Sulistyanti, 2018).

From a sustainability perspective, current practices do not reflect the principles of green chemistry. The application of reduce, reuse, and recycle (3R/4R) approaches is essential to minimize waste generation and environmental impact. Without these practices, laboratory activities may contradict the goals of environmentally responsible education.

Therefore, improving waste management requires a systematic approach, including the implementation of waste segregation systems, provision of labeled waste containers, simple treatment processes such as neutralization, and the development of

clear standard operating procedures (SOPs). In addition, integrating environmental education into laboratory activities can enhance students' awareness and responsibility toward sustainable practices.

Post-Practicum Evaluation

The findings show that post-practicum evaluation at SMA Negeri 2 Percut Sei Tuan is conducted using student worksheets (LKPD) and practicum reports. Through these instruments, teachers assess students' understanding of concepts, procedures, and experimental results after laboratory activities.

However, the evaluation is primarily focused on cognitive outcomes and written reports. There is no structured assessment of students' practical skills, safety compliance, or the effectiveness of laboratory implementation. In addition, feedback mechanisms and reflective discussions after practicum activities are not systematically conducted.

The use of LKPD and practicum reports indicates that evaluation has been integrated into laboratory learning. These instruments are effective for measuring students' conceptual understanding and ability to interpret experimental data. However, limiting evaluation to cognitive aspects reduces its overall effectiveness in assessing laboratory learning outcomes.

Laboratory-based learning should also evaluate psychomotor skills and safety behavior. Practical skills, such as the correct use of equipment and adherence to safety procedures, are essential components of science education. Without structured assessment in these areas, important aspects of laboratory competence may be overlooked.

Furthermore, the absence of systematic feedback and reflection limits opportunities for continuous improvement. Post-practicum discussions are important to identify errors, reinforce concepts, and improve future laboratory implementation.

Without this process, learning becomes less meaningful and less reflective.

Therefore, post-practicum evaluation needs to be expanded into a more comprehensive assessment system that includes cognitive, psychomotor, and affective domains. The use of assessment rubrics, reflective discussions, and feedback sessions is recommended to improve the quality of laboratory learning and ensure that evaluation aligns with the objectives of practical science education.

CONCLUSION

This study provides a comprehensive analysis of chemistry laboratory management at SMA Negeri 2 Percut Sei Tuan by integrating aspects of facilities, administration, organization, safety, and waste management within a single framework. The findings reveal that laboratory management has met basic operational standards; however, its implementation is not yet optimal due to gaps between facility availability and effective management practices. The main scientific contribution of this study lies in demonstrating that the quality of school laboratories is not solely determined by the completeness of physical infrastructure, but by the integration of management systems, safety practices, and administrative control. This study also reinforces previous findings that laboratory challenges in secondary education are systemic, involving organizational structure, safety compliance, and resource management simultaneously.

From a practical perspective, the results highlight several priority areas for improvement. These include the need for digital-based inventory systems to enhance administrative efficiency, the provision of essential safety facilities such as fire extinguishers and eye wash stations, and the implementation of structured waste management aligned with environmental sustainability principles. In addition, strengthening the laboratory organizational structure and conducting regular occupational

safety and health (OSH) training are crucial to improving overall laboratory performance. Therefore, this study emphasizes that improving laboratory quality requires a holistic and sustainable approach, combining infrastructure development, management system improvement, and the cultivation of a safety culture. The findings can serve as a reference for schools, policymakers, and educators in developing more effective, safe, and sustainable chemistry laboratory management practices in secondary education.

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