



## Factual Analysis of Educational Laboratory Management at SMAS Brigjend Katamso II Medan

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### Abstract

*This study examines the comprehensive management practices of educational laboratories at SMAS Brigjend Katamso II Medan, focusing on maintenance, safety protocols, human resources, and stakeholder insights. Utilizing theoretical frameworks such as risk management, constructivist learning, and human capital theories, the analysis reveals a proactive approach to equipment maintenance, rigorous safety standards, and skilled human resources. Findings indicate robust preventive maintenance schedules, frequent safety training sessions, and qualified staff contributing to effective laboratory operations. Stakeholder feedback emphasizes the importance of well-equipped facilities, integrated curriculum approaches, and continuous professional development for educators. Recommendations include diversifying laboratory activities, expanding professional development opportunities, enhancing collaboration between staff and teachers, and strengthening safety protocols. By implementing these strategies, SMAS Brigjend Katamso II aims to foster a safe and engaging environment that supports student learning and success in STEM disciplines.*

## Introduction

The management of educational laboratories is a critical component in the infrastructure of modern schooling systems (Peurach et al., 2019). This study focuses on the factual analysis of the laboratory management practices at SMAS Brigjend Katamso II in Medan, an institution renowned for its commitment to educational excellence. The analysis is designed to uncover the strengths and weaknesses in the current management strategies, offering insights that could guide improvements and ensure that the laboratory facilities meet the highest standards of educational utility and safety.

Laboratories in educational institutions play a pivotal role in facilitating practical learning and fostering a hands-on approach to science and technology (Tsakeni, 2022). At SMAS Brigjend Katamso II Medan, the science laboratories are fundamental to the curriculum, providing students with the necessary resources to conduct experiments, develop critical thinking skills, and engage deeply with scientific concepts. However, the effectiveness of these laboratories hinges on how well they are managed and maintained.

Effective laboratory management involves various factors including adequate funding, proper maintenance, timely updates of equipment, and adherence to safety protocols (Pawar et al., 2020). This study aims to evaluate these aspects within the context of SMAS Brigjend Katamso II. Through a combination of qualitative and quantitative research methods, we aim to present a comprehensive overview of the current state of laboratory management at this institution.

One of the primary objectives of this study is to assess the allocation of resources towards laboratory maintenance and equipment. Proper funding is crucial for ensuring that laboratories

are well-equipped and capable of supporting the curriculum (Naigaga, 2019). We will analyze the budget allocation and expenditure reports related to the laboratories to determine if the financial resources are sufficient and appropriately utilized.

In addition to financial resources, the study will examine the operational protocols in place for maintaining and updating laboratory equipment (Holland & Davies, 2020). Regular maintenance and timely updates are essential to prevent equipment from becoming obsolete or malfunctioning, which can hinder the learning process. We will evaluate the frequency and effectiveness of maintenance schedules and the process for acquiring new equipment.

Safety is another paramount concern in laboratory management. Laboratories must adhere to strict safety standards to protect students and staff from potential hazards (Ayi & Hon, 2018). This study will investigate the safety protocols implemented at SMAS Brigjend Katamso II, including the availability of safety equipment, the training provided to staff and students, and the procedures for handling emergencies.

To gather data for this analysis, we conducted surveys and interviews with teachers, laboratory staff, and students. The surveys aimed to capture the experiences and perceptions of those who use the laboratory facilities regularly. Additionally, we reviewed school records and documents related to laboratory management to supplement the primary data.

The results of this study will be presented in several sections, each focusing on a different aspect of laboratory management. We will start with an overview of the current state of laboratory resources, followed by an evaluation of maintenance and update practices, and a detailed analysis of safety protocols. The findings will be supported by data collected from surveys, interviews, and school records.

To provide a clear and structured presentation of our findings, we have included tables that summarize key data points. These tables will highlight areas where the laboratory management at SMAS Brigjend Katamso II excels and areas that require improvement. The data will be analyzed to identify trends and patterns that can inform recommendations for enhancing laboratory management.

Table 1. Laboratory Financial Allocation at SMAS Brigjend Katamso II For the Last Three Years

<b>Year</b>	<b>Budget Allocated (IDR)</b>	<b>Expenditure on Equipment (IDR)</b>	<b>Expenditure on Maintenance (IDR)</b>	<b>Remaining Budget (IDR)</b>
2021	100,000,000	45,000,000	30,000,000	25,000,000
2022	120,000,000	60,000,000	35,000,000	25,000,000
2023	150,000,000	70,000,000	50,000,000	30,000,000

As shown in Table 1, the budget allocation for laboratory management has seen a steady increase over the past three years, indicating a growing recognition of the importance of well-maintained laboratory facilities. However, the expenditure patterns suggest a need for a more balanced approach to spending on equipment and maintenance to optimize the use of available funds.

The study will also delve into the human resource aspect of laboratory management. This includes the qualifications and training of laboratory staff, the ratio of staff to students, and the involvement of teachers in laboratory management. Properly trained staff are essential for the smooth operation of laboratories and the safety of all users. We will assess whether the current staffing levels and training programs are adequate to meet the needs of the school.

## Methods

The research methodology for the study titled "Factual Analysis of Educational Laboratory Management at SMAS Brigjend Katamso II Medan" is designed to systematically investigate the various aspects of laboratory management within the institution. This section outlines the research design, data collection methods, sampling procedures, data analysis techniques, and ethical considerations undertaken in this study.

### Research Design

This study employs a mixed-methods research design (Justan et al., 2024), combining both qualitative and quantitative approaches to provide a comprehensive analysis of laboratory management at SMAS Brigjend Katamso II. The qualitative component includes interviews and open-ended surveys to gather in-depth insights from stakeholders, while the quantitative component involves structured surveys and analysis of financial records to provide measurable data.

### Data Collection Methods

The data collection methods used in this study are as follows (Retnawati, 2017):

Surveys: Surveys were conducted to collect data from a broad range of participants. (a) Structured Surveys: These were administered to students, teachers, and laboratory staff to gather quantitative data on their experiences and perceptions of the laboratory facilities and management. The survey questions were designed to measure various aspects of laboratory management, including equipment availability, maintenance frequency, and safety compliance; (b) Open-Ended Surveys: These were distributed to a subset of the participants to obtain qualitative insights into specific issues or concerns related to laboratory management. The open-ended questions allowed respondents to provide detailed feedback and suggestions.

Interviews: (a) Semi-Structured Interviews: Conducted with key stakeholders including school administrators, laboratory managers, and selected teachers. These interviews aimed to explore their views on the strengths and weaknesses of the current laboratory management practices. The semi-structured format allowed for flexibility in probing deeper into specific topics of interest.

Document Analysis: (a) Financial Records: Examination of budget allocation and expenditure reports over the past three years to assess the financial management of laboratory resources. This included analyzing how funds were allocated and spent on laboratory equipment and maintenance; (b) Maintenance Logs: Review of maintenance schedules and records to evaluate the effectiveness of equipment upkeep and the frequency of updates. This helped in understanding whether regular maintenance was conducted and if equipment was kept up-to-date; (c) Safety Protocols: Analysis of safety guidelines, incident reports, and training records to determine adherence to safety standards. This involved examining the availability of safety equipment, the training provided to staff and students, and the procedures for handling emergencies.

### Sampling Procedures

The study employs purposive sampling to select participants who have direct experience with the laboratory facilities at SMAS Brigjend Katamso II. The sample includes: (a) Students: A representative sample of 100 students from different grades who regularly use the laboratory facilities; (b) Teachers: 20 science teachers who conduct classes in the laboratories; (c) Laboratory Staff: 5 individuals responsible for the daily operation and maintenance of the

laboratories; (c) School Administrators: 3 key decision-makers involved in the management and funding of laboratory resources.

Purposive sampling was chosen to ensure that participants with relevant and valuable insights were included in the study.

### **Data Analysis Techniques**

The data analysis techniques used in this study include both quantitative and qualitative methods (Jogiyanto Hartono, 2018):

**Quantitative Data Analysis:** (a) **Descriptive Statistics:** Used to summarize the survey data, including measures of central tendency (mean, median) and dispersion (standard deviation). These statistics help in understanding the general trends and patterns in the data; (b) **Comparative Analysis:** Comparison of financial records across different years to identify trends in budget allocation and expenditure. For example, we used the following formula to calculate the year-over-year percentage change in budget allocation:

$$\text{Percentage Change} = \left( \frac{\text{Current Year Budget} - \text{Previous Year Budget}}{\text{Previous Year Budget}} \right) \times 100$$

**Frequency Analysis:** Evaluation of the frequency of maintenance activities and safety training sessions. This involves counting the number of maintenance activities performed and training sessions conducted within a given period.

**Qualitative Data Analysis: Thematic Analysis:** Identification of recurring themes and patterns from the open-ended survey responses and interview transcripts. This involves coding the qualitative data and grouping similar responses to identify common themes.

**Content Analysis:** Detailed examination of document content to extract relevant information about safety protocols and maintenance procedures. This helps in understanding the specific actions taken to maintain safety and functionality in the laboratories.

## **Results and Discussion**

The findings from the study provide a comprehensive view of the current state of laboratory management at the institution. These findings are derived from surveys, interviews, and document analysis conducted over three months. The results are categorized into four main areas: resource allocation and expenditure, maintenance and updates, safety protocols, and human resources.

### **Resource Allocation and Expenditure**

The analysis of financial records revealed trends in budget allocation and expenditure on laboratory resources over the past three years. Table 1 below summarizes the budget and expenditure data. The budget allocation for laboratory resources has increased steadily over the past three years, reflecting the school's commitment to improving its laboratory facilities. The percentage change in budget allocation from 2021 to 2022 is calculated as follows:

$$\text{Percentage Change (2021 to 2022)} = \left( \frac{120,000,000 - 100,000,000}{100,000,000} \right) \times 100 = 20\%$$

Similarly, the percentage change from 2022 to 2023 is:

$$\text{Percentage Change (2022 to 2023)} = \left( \frac{150,000,000 - 120,000,000}{120,000,000} \right) \times 100 = 25\%$$

These increases demonstrate a significant investment in laboratory resources. However, the expenditure patterns suggest that while the budget for equipment has increased, maintenance

expenditures have also risen, indicating a balanced approach to maintaining and updating laboratory facilities.

### Maintenance and Updates

The analysis of maintenance logs and records showed that regular maintenance activities are conducted, and equipment is updated frequently. The average number of maintenance activities per year is shown in Table 2 below:

Table 2. Average Maintenance Activities Per Year

Year	Number of Maintenance Activities
2021	15
2022	18
2023	22

The increase in maintenance activities indicates a proactive approach to equipment upkeep. The average annual increase in maintenance activities is calculated as:

$$\text{Average Increase} = \left( \frac{(18-15)+(22-18)}{2} \right) = \frac{3+4}{2} = 3.5 \text{ activities per year}$$

This trend suggests an improvement in the frequency and effectiveness of maintenance schedules, ensuring that laboratory equipment remains functional and up-to-date.

### Safety Protocols

Safety is a paramount concern in laboratory management. The document analysis of safety protocols, incident reports, and training records revealed several key findings: (a) Availability of Safety Equipment: All laboratories are equipped with essential safety equipment, including fire extinguishers, first aid kits, and eye wash stations; (b) Safety Training: Regular safety training sessions are conducted for both staff and students. The number of safety training sessions held annually is detailed in Table 3:

Table 3. Safety Training Sessions Held Annually

Year	Number of Safety Training Sessions
2021	4
2022	5
2023	6

The increase in safety training sessions indicates a strong commitment to safety education. The average annual increase in training sessions is:

$$\text{Average Increase} = \left( \frac{(5-4)+(6-5)}{2} \right) = \frac{1+1}{2} = 1 \text{ session per year}$$

Incident Reports: The analysis of incident reports showed a decrease in the number of safety incidents over the years, suggesting that improved safety protocols and training are having a positive impact.

### Human Resources

The human resource aspect of laboratory management was evaluated through surveys and interviews with teachers and laboratory staff. Key findings include: (a) Staff Qualifications and Training: All laboratory staff possess relevant qualifications and receive ongoing training to ensure they are equipped to handle laboratory operations effectively; (b) Staff-to-Student Ratio: The current staff-to-student ratio is adequate, with one laboratory technician available for every two classes. This ratio ensures that staff can provide adequate support to students during

laboratory sessions; (c) Teacher Involvement: Teachers are actively involved in laboratory management, including planning experiments, supervising students, and coordinating with laboratory staff.

### **Survey and Interview Findings**

The surveys and interviews provided valuable insights into the perceptions and experiences of students, teachers, and laboratory staff. Key themes identified include: (a) Satisfaction with Equipment Availability: Most respondents expressed satisfaction with the availability and quality of laboratory equipment. Students particularly appreciated the access to modern and functional equipment; (b) Maintenance Effectiveness: Both teachers and laboratory staff highlighted the effectiveness of the maintenance schedules, noting that equipment rarely malfunctions and is promptly repaired when issues arise; (c) Safety Awareness: There is a high level of safety awareness among students and staff, attributed to regular safety training and the presence of clear safety protocols.

The discussion section of this study on “Factual Analysis of Educational Laboratory Management at SMAS Brigjend Katamso II Medan” synthesizes the research findings to provide a deeper understanding of the current state of laboratory management at the institution. By integrating the quantitative data, qualitative insights, and document analysis, this discussion highlights the key strengths and areas for improvement in laboratory management practices.

### **Resource Allocation and Expenditure**

The analysis of resource allocation and expenditure at SMAS Brigjend Katamso II Medan reveals a strategic approach to enhancing laboratory facilities. Over the past three years, there has been a notable increase in the budget allocated for laboratory resources, reflecting the administration’s commitment to improving the quality of science education. Understanding the implications of this financial strategy requires a detailed discussion that integrates theoretical perspectives on resource allocation and effective financial management in educational settings.

The steady increase in budget allocation from IDR 100,000,000 in 2021 to IDR 150,000,000 in 2023 indicates a clear prioritization of laboratory resources within the school’s financial planning. This 50% increase over three years can be interpreted through the lens of resource-based theory (Barney, 1991), which posits that organizations achieve competitive advantage by acquiring and effectively utilizing valuable, rare, inimitable, and non-substitutable resources. By significantly investing in laboratory resources, SMAS Brigjend Katamso II aims to enhance its educational offerings, thereby improving student outcomes and the school’s overall reputation.

A breakdown of the expenditure reveals that spending on equipment has risen from IDR 45,000,000 in 2021 to IDR 70,000,000 in 2023, while maintenance costs have increased from IDR 30,000,000 to IDR 50,000,000 over the same period. This dual focus on acquiring new equipment and maintaining existing resources aligns with total cost of ownership (TCO) theory (Noorbakhsh et al., 2020), which emphasizes the importance of considering all costs associated with an asset throughout its lifecycle.

The increase in equipment expenditure is essential for providing students with access to modern, up-to-date scientific instruments, which can enhance their learning experiences and foster greater engagement in STEM subjects. According to educational effectiveness research (Zainuddin, 2019), well-resourced laboratories are positively correlated with improved student performance, particularly in practical subjects like science.

Similarly, the rise in maintenance expenditure ensures that the equipment remains in good working condition, thereby extending its useful life and ensuring safety and reliability. Regular

maintenance prevents equipment breakdowns and reduces downtime, which can disrupt the educational process. This proactive approach to maintenance reflects principles of preventive maintenance theory (SASITHARAN & DAYANAN, 2020), which advocates for regular, planned maintenance activities to prevent equipment failures and optimize performance.

The school's approach to financial management, characterized by increasing investments in laboratory resources, is indicative of strategic financial management (Owings & Kaplan, 2019). This involves aligning financial resources with the school's long-term educational goals. By progressively increasing the budget for laboratory facilities, the school demonstrates a commitment to creating an enriched learning environment that supports scientific inquiry and innovation.

Moreover, the balanced approach to expenditure, where both equipment acquisition and maintenance are prioritized, aligns with the principle of balanced scorecard (Wisner et al., 2021). This principle advocates for a balanced investment in different areas to achieve sustainable performance. In the context of SMAS Brigjend Katamso II, balanced expenditure ensures that the laboratories are not only equipped with modern instruments but also maintained to high standards, providing a reliable and safe environment for students and teachers.

### **Maintenance and Updates**

The maintenance and updates of laboratory equipment at SMAS Brigjend Katamso II Medan form a critical component of the overall laboratory management strategy. The study's findings indicate a significant emphasis on regular maintenance and timely updates, reflecting a proactive approach to ensuring the functionality and safety of laboratory resources. This section delves deeper into the trends and theoretical underpinnings of maintenance practices at the school, highlighting their impact on educational outcomes and resource sustainability.

The data reveals a consistent increase in the number of maintenance activities conducted annually, from 15 activities in 2021 to 22 in 2023. This trend suggests a systematic approach to equipment upkeep, aligned with the principles of preventive maintenance theory (Zonta et al., 2020). Preventive maintenance involves scheduled inspections and servicing to prevent equipment failures before they occur, thereby enhancing reliability and extending the lifespan of assets.

The average annual increase in maintenance activities, calculated at 3.5 activities per year, indicates a robust maintenance schedule that likely includes regular checks, servicing, and minor repairs. This proactive maintenance regime minimizes the risk of unexpected breakdowns, ensuring that laboratory sessions can proceed without disruptions, which is crucial for maintaining the integrity of the educational process.

Preventive maintenance is essential for maintaining the operational efficiency and safety of laboratory equipment. According to reliability-centered maintenance (RCM) theory (NORIEGA DEL CASTILLO, 2018), the primary goal of maintenance is to maintain the inherent reliability of equipment while minimizing the risk of failures. By implementing a preventive maintenance schedule, SMAS Brigjend Katamso II can ensure that laboratory equipment remains in optimal condition, thereby supporting continuous and effective teaching and learning.

The proactive maintenance and updates of laboratory equipment have a direct impact on educational outcomes. Well-maintained equipment ensures that students can engage in hands-on experiments without interruptions, which is vital for experiential learning in science education. According to constructivist learning theory (Steffe & Ulrich, 2020), students

construct knowledge through active engagement and experimentation. Therefore, reliable access to functional laboratory equipment is essential for fostering scientific inquiry and enhancing students' understanding of complex scientific concepts.

Moreover, regular updates to laboratory equipment ensure that students are exposed to the latest technologies and methodologies in science education. This exposure is critical for preparing students for higher education and careers in STEM fields. Technology integration theory (Makewa, 2019) posits that the effective integration of technology into education enhances learning outcomes by providing students with tools and resources that support active learning and critical thinking.

Investing in preventive maintenance is also cost-effective in the long run. Total productive maintenance (TPM) theory (Díaz-Reza et al., 2019) emphasizes the importance of maintaining and improving production systems through the involvement of all employees. In the context of SMAS Brigjend Katamso II, involving laboratory staff and teachers in maintenance activities can enhance the effectiveness of maintenance practices. By preventing major equipment failures, the school can avoid costly repairs and replacements, thereby optimizing the use of financial resources.

Additionally, maintaining equipment in good condition reduces the likelihood of accidents and safety incidents, which can have significant financial and legal implications. Risk management theory (Haywood, 2022) highlights the importance of identifying and mitigating risks to minimize potential losses. Regular maintenance activities, combined with safety inspections, help mitigate risks associated with equipment malfunctions, ensuring a safe learning environment for students and staff.

### **Safety Protocols**

Safety protocols in educational laboratories are crucial for ensuring the well-being of students and staff, as well as for maintaining a conducive learning environment. The study's findings on safety protocols at SMAS Brigjend Katamso II Medan highlight the institution's commitment to maintaining high safety standards through comprehensive safety measures, regular training sessions, and stringent adherence to safety guidelines. This section discusses the trends, theoretical underpinnings, and implications of the safety protocols implemented at the school.

The data indicates a significant emphasis on safety, with the number of safety training sessions increasing from four in 2021 to six in 2023. This upward trend reflects an understanding of the importance of safety education and preparedness in preventing accidents and ensuring a safe laboratory environment. The consistent rise in training sessions is a positive indicator of the school's proactive approach to safety management.

The implementation of robust safety protocols can be examined through various theoretical frameworks, including risk management theory, behavioral safety theory, and organizational safety culture theory. Risk Management Theory, this theory emphasizes the identification, assessment, and prioritization of risks, followed by coordinated efforts to minimize, monitor, and control the probability or impact of unfortunate events (Hardy et al., 2020). At SMAS Brigjend Katamso II, risk management involves regular safety audits, hazard assessments, and the establishment of safety protocols that address potential risks associated with laboratory activities.

Behavioral Safety Theory, this theory focuses on modifying behavior to enhance safety outcomes. It posits that safety can be improved by influencing individuals' behaviors through training, reinforcement, and feedback (Mashi et al., 2020). The increase in safety training



sessions at the school aligns with this theory, as these sessions aim to instill safe practices and awareness among students and staff, thereby reducing the likelihood of accidents.

**Organizational Safety Culture Theory:** This theory highlights the role of organizational culture in promoting safety. A strong safety culture is characterized by shared values, beliefs, and practices that prioritize safety at all levels of the organization (Bisbey et al., 2021). SMAS Brigjend Katamso II's commitment to regular safety training and the presence of clear safety protocols indicate a strong safety culture that permeates the school's operations.

## **Human Resources**

The human resources component is a critical pillar in the effective management of educational laboratories. At SMAS Brigjend Katamso II Medan, the human resources dedicated to laboratory management play a vital role in ensuring the smooth operation and continuous improvement of laboratory facilities. This section delves into the qualifications, training, and involvement of laboratory staff and teachers, integrating relevant theoretical perspectives to provide a comprehensive understanding of their impact on laboratory management.

The study highlights that the laboratory staff at SMAS Brigjend Katamso II are well-qualified, with the majority holding relevant degrees in science and education. This high level of qualification is essential for several reasons. Firstly, it ensures that the staff possess the necessary technical knowledge to operate and maintain laboratory equipment effectively. Secondly, qualified staff can provide accurate and safe guidance to students during laboratory activities, which is crucial for fostering a conducive learning environment.

According to human capital theory (Philip & Ikechukwu, 2018), investing in the education and skills of employees enhances their productivity and, by extension, the performance of the organization. In the context of SMAS Brigjend Katamso II, the high qualifications of laboratory staff represent a significant investment in human capital that contributes to the overall effectiveness and safety of laboratory operations.

Continuous professional development (CPD) for laboratory staff and teachers is another key aspect of the human resources strategy at SMAS Brigjend Katamso II. The study indicates that staff regularly participate in training programs and workshops to update their skills and knowledge. This commitment to CPD is aligned with lifelong learning theory (Kitto et al., 2018), which emphasizes the importance of ongoing education and skill development throughout an individual's career.

Regular training ensures that laboratory staff stay abreast of the latest advancements in laboratory technologies and safety practices. This is particularly important in a field that evolves rapidly with technological innovations. By continuously updating their skills, laboratory staff can effectively incorporate new methods and equipment into the educational process, thereby enhancing the quality of science education offered at the school.

The active involvement of teachers in laboratory management is a notable strength at SMAS Brigjend Katamso II. Teachers play a critical role in integrating laboratory activities with the broader curriculum, ensuring that practical experiments complement theoretical learning. This integration is supported by constructivist learning theory (Matthews, 2020), which posits that students construct knowledge through active engagement and hands-on experiences.

By being actively involved in laboratory management, teachers can design experiments that directly support their lesson plans, making learning more engaging and effective. Furthermore, teachers' involvement ensures that laboratory activities are aligned with educational goals and standards, providing students with meaningful and relevant learning experiences.

The study reveals that SMAS Brigjend Katamso II maintains an adequate staff-to-student ratio in its laboratories. This ratio is crucial for several reasons. Firstly, it ensures that students receive sufficient supervision and guidance during laboratory activities, which is essential for maintaining safety and promoting effective learning. Secondly, an appropriate staff-to-student ratio allows for more individualized attention, enabling staff to address the specific needs and questions of students.

According to educational productivity theory (Johnson, 2018), smaller class sizes and favorable staff-to-student ratios contribute to better educational outcomes. By maintaining an optimal staff-to-student ratio, SMAS Brigjend Katamso II can enhance the quality of laboratory instruction and ensure that students receive the support they need to succeed in their scientific endeavors.

The human resources strategy at SMAS Brigjend Katamso II fosters a collaborative environment where laboratory staff and teachers work together to achieve common goals. This collaborative approach is supported by teamwork theory (AYTENFISU, 2020), which emphasizes the importance of collective effort and shared responsibility in achieving organizational objectives.

In a collaborative environment, staff and teachers can share their expertise and insights, leading to innovative solutions and continuous improvements in laboratory management. Regular meetings, joint training sessions, and collaborative planning activities are some of the practices that can enhance teamwork and cooperation among laboratory staff and teachers.

### **Survey and Interview Insights**

The survey and interview insights provide a rich and nuanced understanding of the laboratory management practices at SMAS Brigjend Katamso II Medan. By collecting qualitative data from various stakeholders, including students, teachers, and laboratory staff, the study offers a comprehensive view of the perceptions, experiences, and suggestions related to laboratory facilities and their usage. This section analyzes the key findings from the surveys and interviews, integrating relevant theoretical perspectives to elucidate their implications for laboratory management.

The feedback from students highlights several important aspects of their experiences with the laboratory facilities. Many students expressed satisfaction with the availability and quality of laboratory equipment, noting that it significantly enhances their learning experiences. According to student engagement theory (Delfino, 2019), active participation and engagement in learning activities are critical for student success. The positive feedback from students indicates that well-equipped laboratories contribute to higher levels of engagement and interest in science subjects.

However, some students also pointed out areas for improvement, such as the need for more diverse experimental activities and better access to laboratory resources outside scheduled class times. These suggestions align with constructivist learning theory (Kritt & Budwig, 2022), which emphasizes the importance of hands-on, experiential learning. Providing students with more opportunities to engage in diverse and self-directed experiments can enhance their understanding of scientific concepts and foster a deeper interest in STEM fields.

Teachers provided valuable insights into the integration of laboratory activities with the curriculum and the challenges they face in managing laboratory sessions. Many teachers highlighted the importance of well-structured laboratory activities that complement theoretical lessons, thereby reinforcing students' learning. This approach is supported by integrated curriculum theory (Gordon et al., 2020), which advocates for the integration of different

subjects and learning experiences to create a more cohesive and meaningful educational experience.

Teachers also identified several challenges, including the need for ongoing professional development and better coordination with laboratory staff. They emphasized the importance of continuous training to keep up with advancements in laboratory technologies and safety practices. This perspective aligns with professional development theory (Hasha & Wadesango, 2020), which underscores the necessity of continuous learning and skill enhancement for educators to remain effective in their roles.

Laboratory staff provided critical feedback on the operational aspects of laboratory management, including equipment maintenance, safety protocols, and resource allocation. Many staff members expressed satisfaction with the current maintenance practices and the proactive approach to safety management. They highlighted the importance of regular maintenance and safety checks in preventing equipment failures and ensuring a safe laboratory environment. This feedback aligns with maintenance management theory (Majuru, 2021), which emphasizes the role of regular maintenance in optimizing the performance and longevity of equipment.

However, some staff members also pointed out the need for better communication and collaboration with teachers to ensure that laboratory activities run smoothly and effectively. This suggestion is supported by organizational communication theory (Akarika et al., 2023), which highlights the importance of effective communication in enhancing organizational performance and achieving common goals.

## Conclusion

The comprehensive analysis of laboratory management at SMAS Brigjend Katamso II Medan reveals a robust framework supported by diligent maintenance practices, stringent safety protocols, effective resource allocation, and a skilled human resources strategy. This study integrated theoretical perspectives such as risk management theory, constructivist learning theory, and human capital theory to elucidate the foundations and implications of these management practices. **Maintenance and Resource Allocation:** The school demonstrates a proactive approach to equipment maintenance, ensuring reliability and longevity through regular inspections and updates. This aligns with maintenance management theory, emphasizing the importance of preventive maintenance to optimize equipment performance. **Safety Protocols:** Rigorous safety protocols are in place, supported by regular training and audits, enhancing the safety culture within laboratory environments. The implementation of these protocols reflects a commitment to risk management theory, which prioritizes identifying and mitigating risks to ensure a safe learning environment. **Human Resources Strategy:** The school's investment in qualified staff and continuous professional development underscores its commitment to enhancing educational outcomes. This aligns with human capital theory, highlighting the role of education and skill development in improving organizational effectiveness. **Student and Teacher Engagement:** Feedback from students and teachers emphasizes the importance of well-equipped laboratories and integrated curriculum approaches. This supports constructivist learning theory, advocating for active engagement and hands-on experiences to foster deeper understanding and interest in STEM subjects.

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