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ASSESSMENT OF BIOLOGY LABORATORY MANAGEMENT AND FACILITIES IN PUBLIC SENIOR HIGH SCHOOLS

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Abstract

Biology laboratories play an important role in supporting practical learning activities and developing students' scientific skills in science education. Effective laboratory management and adequate facilities are necessary to ensure that practical activities are conducted safely and optimally. This study aimed to analyse: (1) the management of biology laboratories, (2) the completeness of biology laboratory facilities and materials, and (3) the implementation of laboratory management practices in public senior high schools in Malang City. This study employed a descriptive research design using percentage-based statistical analysis. The population consisted of 10 public senior high schools in Malang City, and 3 schools were purposively selected based on school zoning representation and Accreditation A status. The respondents included biology teachers, laboratory heads, and laboratory assistants. Data were collected through observations, questionnaires, interviews, and documentation. The research instruments were validated through expert judgment by biology education lecturers. The results showed that overall management of biology laboratories was rated very good, with an average score of 87.69%. Material ordering, storage, and safety and maintenance management were generally implemented effectively. The completeness of biology laboratory facilities and materials was also categorised as very complete, with an average percentage of 89.20%. However, several weaknesses remained, particularly in hazardous waste disposal, laboratory safety practices, and infrastructure maintenance. Overall, biology laboratories in public senior high schools in Malang City were adequately managed and equipped to support biology practical learning activities.

Keywords : Biology Laboratory, Laboratory Management, Laboratory Facilities, Practical Learning, Senior High School

INTRODUCTION

The rapid advancement of science and technology in the 21st century has significantly influenced various aspects of human life, including the education sector. Educational institutions are expected to equip students with competencies such as critical thinking, creativity, communication, collaboration, and problem-solving skills to meet global challenges and workforce demands (Singh et al., 2022). These competencies are closely related to the development of cognitive, interpersonal, and intrapersonal skills that support lifelong learning and adaptability in modern society (Wright & Lee, 2014). In addition, the development of 21st-century skills aligns with the four pillars of education, particularly *learning to do*, which emphasises practical and experiential learning activities (Faraniza, 2021). Therefore, learning activities should not only focus on theoretical understanding but also provide opportunities for students to construct scientific knowledge through direct experiences actively.

In science education, practical activities are commonly facilitated through laboratory-based learning. Laboratories serve as places for applying scientific theories, conducting experiments, and developing scientific inquiry skills using appropriate tools and materials (Depdiknas, 2002). Biology laboratories, in particular, play an important role in improving students' cognitive, affective, and psychomotor competencies (Emda, 2017). Previous studies reported that learning activities involving laboratory equipment positively contribute to students' academic achievement and conceptual understanding (Liang, 2019; Ihejiamaizu & Ohui, 2016). Inquiry-based laboratory activities also improve students' scientific attitudes and understanding of learning materials (Acar Sesen & Tarhan, 2013). Furthermore, laboratory learning environments help students develop science process and manipulative skills, as well as self-confidence in science learning (Lee et al., 2020). Effective management of laboratory activities may also improve students' higher-order thinking skills and scientific competencies needed in future careers (Ezeano & Ezeudu, 2013). In addition, laboratory-based learning contributes to students' self-development and research abilities (Gandhi et al., 2016).

The effectiveness of laboratory-based learning is influenced by the availability of adequate facilities and supportive learning environments. Studies show that structured and interactive laboratory settings improve student engagement, skills, and learning outcomes compared to traditional methods (Qu et al., 2024). Remote experimentation platforms also enhance accessibility and efficiency, enabling students to achieve better results (Achuthan et al., 2021). n addition, inquiry-based laboratory activities encourage critical thinking and conceptual understanding through hands-on experiences (Thacker, 2023). hese findings indicate that well-designed laboratory facilities and effective management systems are essential to support safe, organised, and productive practical activities (Gade & Wallace, 2023). Therefore, laboratory facilities and management systems should support safe, organised, and effective practical activities.

Laboratory management is a systematic process involving planning, organising, implementing, maintaining, supervising, and evaluating laboratory activities (Amba et al., 2014; Pertiwi, 2019). Proper laboratory management helps teachers and students utilise laboratory facilities effectively because laboratories involve complex activities, equipment, materials, and safety procedures (Goel et al., 2021). Laboratory managers are also responsible for conducting periodic inspections and ensuring the proper maintenance of laboratory equipment to minimise potential hazards (Lee et al., 2020). In recent years, laboratory safety management has become increasingly important because laboratory activities expose students to hazardous chemicals and potential accidents (Abdullah & Aziz, 2020). Consequently, laboratory safety training and supervision are necessary to improve safety awareness and reduce risks during laboratory activities (Yang et al., 2019; Viitaharju et al., 2021).

The competency of laboratory personnel also influences the success of laboratory management. Skilled laboratory staff are needed to ensure that laboratory activities are conducted effectively and safely. Laboratory administrators are expected to improve their competencies through training programs, workshops, seminars, and professional development activities (Raharjo, 2017). In addition, the involvement of principals, teachers, laboratory assistants, and students is

important in supporting the effectiveness of laboratory-based learning (Pertiwi, 2019). Proper laboratory management not only supports practical learning activities but also contributes to the development of students' science process skills and scientific attitudes.

Despite the important role of laboratories in science learning, many schools still face challenges in laboratory management. Common issues include limited skilled personnel, poor planning and organization, inadequate equipment and materials, and insufficient funding, especially in rural areas (Prasiska et al., 2024; Rini et al., 2024). Inadequate planning and organization are prevalent, with many schools failing to update laboratory organizational structures or adequately prepare work programs, leading to underutilization of facilities (Mohzana et al., 2023; Nurhamudin, 2024; Muzammal & Hashmi, 2025). The lack of professional laboratory managers and training also leads to ineffective maintenance and underutilization of facilities. In addition, weak supervision and evaluation practices further reduce management effectiveness (Efendi & Jayanti, 2024). By improving these areas, schools can foster a more engaging and effective science learning environment, ultimately enhancing student motivation and learning outcomes (Sobarman, 2023).

Public senior high schools in Malang City generally have Accreditation A status and relatively good educational facilities. However, studies specifically evaluating the management of biology laboratories and the completeness of laboratory facilities in these schools remain limited. Therefore, it is necessary to evaluate the management practices and availability of biology laboratory facilities in public senior high schools in Malang City to provide empirical information regarding their current condition and implementation.

This study aims to analyse: (1) the management of biology laboratories in public senior high schools in Malang City, (2) the completeness of biology laboratory tools and materials, and (3) the implementation of biology laboratory management practices in supporting practical learning activities. The findings of this study are expected to contribute to improving the quality of laboratory management and strengthening laboratory-based biology learning in schools.

METHODS

Research Design

This study employed a descriptive research design using percentage-based statistical analysis to evaluate the management and completeness of biology laboratory facilities in public senior high schools in Malang City. The study focused on describing the existing conditions of biology laboratory management practices and laboratory facilities without manipulating any variables. The study population consisted of 10 public senior high schools in Malang City. Three schools were selected purposively to represent the three educational zoning areas in Malang City. The selected schools had Accreditation A status, adequate biology laboratory facilities, and permission to collect data. Purposive sampling was used because the selected schools were considered representative of public senior high schools with established biology laboratory management systems. The respondents consisted of laboratory heads, laboratory assistants, and biology teachers from the selected schools who were directly involved in laboratory management and biology practical activities.

Instrument of The Study

The instruments used in this study included questionnaires, observation sheets, interview guidelines, and documentation sheets. The questionnaire was used to obtain information on biology laboratory management practices, while the observation sheets were used to assess the completeness of laboratory facilities, tools, and materials in accordance with the Regulation of the Minister of National Education Number 24 of 2007 concerning laboratory standards. The questionnaire used in this study was closed-ended and employed a rating scale. The same questionnaire items were administered to all respondent groups, including biology teachers, laboratory heads, and laboratory assistants. The assessment criteria for the completeness of laboratory facilities and infrastructure were categorised using a four-point scale as follows:

a. Score 4: Very complete (the quantity of tools and materials met or exceeded the required standard ratio).
b. Score 3: Complete (the quantity of tools and materials was below the required

standard but exceeded half of the required ratio).

c. Score 2: incomplete (the quantity of tools and materials was approximately half of the required ratio).
d. Score 1: very incomplete (the quantity of tools and materials was less than half of the required ratio).

Data Collection and Data Analysis

Data collection was conducted through technical triangulation, including observations, questionnaires, interviews, and documentation. Observations were carried out to evaluate the implementation of biology laboratory management and the availability of laboratory facilities and materials. Questionnaires were distributed to biology teachers and laboratory personnel to obtain information regarding laboratory management practices. Interviews were conducted openly to gather deeper information on management implementation, challenges, and maintenance practices at each. Documentation techniques were used to support and verify the collected data. Permission for data collection was obtained from each participating school before the research was conducted.

The collected data were analysed using descriptive statistical analysis in the form of percentages. Results from questionnaires and observations were calculated and converted to percentages to determine the categories of biology laboratory management and facility completeness. The categories of biology laboratory management were adapted from Ratumanan and Laurens (2011) and are presented in Table 1. The percentage results were then interpreted descriptively to explain the condition of biology laboratory management and the completeness of laboratory facilities in the selected public senior high schools in Malang City.

Table 1. The Category of Biology Laboratory Management

Intervals (%)	Criteria
81.26-100	Very good
62.51-81.25	Good
43.76-62.50	Not good
25.00-43.75	Very Not Good

(Source: Adaptation of Ratumanan and Laurens, 2011)

RESULTS AND DISCUSSIONS

Biological Laboratory Management

Biology laboratory management in public senior high schools in Malang City included several aspects: material ordering, storage, and safety and maintenance management. The assessment results are presented in Table 2.

Table 2. Biology Laboratory Management in Public Senior High Schools in Malang City

No.	School	Percentage	Category
1.	School A	91.48%	Very good
2.	School B	91.76%	Very good
3.	School C	79.83%	Good
Average		87.69%	Very good

The findings indicate that biology laboratory management in public senior high schools in Malang City was generally effective, reflected by the very good average score of 87.69%. High scores across schools show that planning, organisation, supervision, and maintenance adequately supported practical learning activities. Compared with previous studies in Indonesia that reported weaknesses in laboratory organisation, safety, and personnel competency (Amba et al., 2014), the schools in this study demonstrated better management practices. This difference is likely influenced by the Accreditation A status of the schools, which provides stronger facilities, administrative systems, and institutional support.

This finding also strengthens previous studies stating that effective laboratory management contributes not only to laboratory safety and organisation but also to improving the quality of science learning experiences and students' scientific competencies (Amba et al., 2014; Goel et al., 2021).

Similar results were reported by Muliyah et al. (2025) and Suyantri et al. (2024), who found that proper implementation of safety procedures, equipment management, and laboratory maintenance positively supports practical learning effectiveness. However, the present study additionally revealed that differences in management quality among schools were still evident, particularly in laboratory maintenance consistency and safety management practices. Therefore, laboratory management should not merely focus on administrative activities but should also function as a strategic component in creating meaningful, safe, and student-centred science learning environments (Suslistya & Mahadewi, 2023).

a. Material Order Management

The results of the material ordering management assessment are presented in Table 3.

Table 3. Material Ordering Management of Biology Laboratories

No.	Skills	Average (%)	Criteria
1	Biology teachers can order the relevant laboratory materials.	100%	Very good
2	Obtain quotes from multiple laboratory equipment suppliers.	58.33%	Not good
3	Placing priority on the goods ordered.	100%	Very good
4	Ensure that the necessary chemicals and equipment are 100% available.	100%	Very good
5	Work with experienced and trusted laboratory equipment suppliers.	100%	Very good
6	Inspect and reject counterfeit laboratory equipment and chemicals.	100%	Very good
7	Comparing the cost of materials with their quality.	100%	Very good
	Average	94.05%	Very good

The results showed that material ordering management in biology laboratories was categorised as very good, with an average score of 94.05%. Most schools conducted procurement systematically by prioritising laboratory needs, ensuring material availability, and checking equipment quality before use. However, differences remained in supplier selection practices. Schools involving laboratory assistants directly in procurement achieved more appropriate outcomes than those relying mainly on administrative staff, highlighting the importance of laboratory personnel in ensuring materials and equipment meet practical learning needs.

Compared with previous studies reporting weaknesses in laboratory administration and procurement systems due to inadequate planning and poor management practices (Fiska et al., 2021), the schools observed in this study demonstrated better procurement management and laboratory readiness. Similar findings were also reported by Amanda et al. (2024), who found that schools with effective laboratory management systems tended to have higher levels of laboratory preparedness. Nevertheless, the relatively low score in obtaining quotations from multiple suppliers indicates that procurement efficiency and supplier diversification still require improvement. Previous studies emphasised that effective laboratory management requires proper administrative systems, budgeting, and collaboration among laboratory personnel and school administrators to optimise procurement processes (Muhlis et al., 2025). Therefore, proper procurement planning and active involvement of laboratory personnel are important not only for maintaining laboratory readiness but also for minimising material waste and improving the quality of practical learning activities (Sembiring & Siliwangi, 2017).

b. Storage Management

The results of the storage management assessment are presented in Table 4.

Table 4. Storage Management of Laboratory Tools and Materials

No.	Skills	Average (%)	Criteria
1.	Properly labelling reagents	100%	Very good
2.	Separating reactive chemicals	100%	Very good
3.	Providing stock record books	100%	Very good
4.	Considering production and expiration dates	100%	Very good

No.	Skills	Average (%)	Criteria
5.	Storing photolysis-sensitive chemicals properly	100%	Very good
6.	Proper storage of glass equipment	100%	Very good
7.	Recording damaged materials accurately	100%	Very good
8.	Proper disposal of broken glass	83.33%	Very good
9.	Recording and storing used chemicals carefully	66.67%	Good
	Average	94.44%	Very good

The results showed that laboratory storage management was categorised as very good, with an average percentage of 94.44%, indicating that most schools had implemented proper procedures in managing laboratory materials and equipment. High scores in reagent labelling, chemical separation, inventory recording, and storage of sensitive materials suggest that laboratory personnel already understood the importance of systematic storage management in maintaining laboratory safety and material quality. These findings indicate that the selected schools demonstrated better storage management practices compared with several previous studies reporting weaknesses in laboratory organisation, storage systems, and occupational safety implementation in school laboratories (Suyantri et al., 2024;Santoso et al., 2024). Proper storage management is important because inappropriate storage practices may increase the risk of chemical contamination, equipment damage, and laboratory accidents (Mora et al., 2018). Therefore, the relatively high storage management scores in this study reflect the schools' efforts to maintain safer and more organised laboratory environments that support effective practical learning activities.

Despite the generally positive findings, weaknesses were still found in chemical waste management and disposal practices. Lower scores in recording and storing used chemicals, as well as improper disposal of broken glass and chemical waste, indicate inconsistent implementation of laboratory safety procedures. Similar issues have been reported in previous studies related to limited laboratory management competency and safety practices (Mora et al., 2018). Ahnaf & Puspitasari (2023) suggested that the continued use of manual inventory systems may reduce efficiency in monitoring materials and waste management. Therefore, improved training, stronger safety awareness, and more systematic digital inventory systems are needed to optimise laboratory management and ensure safer laboratory practices

c. Safety and Maintenance Management

The results of the safety and maintenance management assessment are presented in Table 5.

Table 5. Safety and Maintenance Management

No.	Skills	Average (%)	Criteria
1.	Isolating flammable, toxic, and carcinogenic chemicals	66.67%	Good
2.	Using warning symbols and signs	75%	Good
3.	Ensuring proper disposal of laboratory waste	100%	Very good
4.	Limiting laboratory material access to authorised personnel	100%	Very good
5.	Ensuring proper drainage systems	100%	Very good
6.	Inspecting electrical equipment before use	100%	Very good
7.	Cleaning and returning laboratory equipment properly	100%	Very good
8.	Preventing and repairing water and gas leaks	100%	Very good
9.	Repairing minor laboratory equipment damage	91.67%	Very good
10.	Asking students to stand during practical activities	58.33%	Not good
	Average	89.17%	Very good

The findings revealed that safety and maintenance management in the observed biology laboratories was generally implemented effectively, as indicated by the very good average percentage score of 89.17%. Most schools demonstrated strong performance in maintaining laboratory equipment, inspecting electrical systems, managing drainage facilities, and handling laboratory waste properly. These results suggest that the schools had established adequate preventive maintenance practices to support the continuity and safety of practical learning activities. Compared with previous studies highlighting weaknesses in laboratory safety implementation and facility maintenance (Suyantri et al.,

2024; Santoso et al., 2024), the schools in this study showed relatively better readiness in maintaining laboratory operational conditions.

Nevertheless, several safety aspects still require attention, particularly in the segregation of hazardous chemicals, the use of warning signs, and the implementation of proper student safety behaviour during laboratory activities. These findings indicate that laboratory safety culture has not yet been implemented consistently across schools. Similar limitations in occupational health and safety practices were also reported by Santoso et al. (2024), while (Mora et al., 2018). Mora et al. (2018) emphasised that laboratory safety depends on both adequate facilities and users' compliance with safety procedures. In contrast, Muliyah et al. (2025) demonstrated that consistent implementation of safety protocols and proper use of safety equipment could significantly improve laboratory safety conditions. In addition, infrastructural problems such as inadequate ventilation and roof leakage may reduce laboratory comfort and potentially increase safety risks during practical activities. Therefore, continuous safety training, supervision, and infrastructure improvement remain necessary to support safer and more effective biology laboratory environments.

2. Completeness of Tools and Materials

The completeness of biology laboratory facilities and materials is presented in Table 6.

Table 6. Completeness of Biology Laboratory Facilities and Materials

No.	Type of Facilities	Percentage	Category
1.	Furniture	91.67%	Very complete
2.	Educational equipment	85.08%	Very complete
3.	Educational media	75.00%	Complete
4.	Consumable materials	94.23%	Very complete
5.	Other equipment	100.00%	Very complete
	Average	89.20%	Very complete

The results showed that the completeness of biology laboratory facilities and materials in public senior high schools in Malang City was categorised as very complete, with an average percentage of 89.20%. High percentages in furniture, consumable materials, and supporting equipment indicate that most schools already possessed adequate laboratory resources to support biology practical learning activities. Compared with previous studies reporting lower levels of laboratory completeness ranging from 66% to 78% (Harahap, 2022), the schools observed in this study demonstrated relatively better laboratory readiness. This condition may be influenced by the Accreditation A status of the selected schools, which generally have better institutional support, laboratory funding, and facility management systems. These findings suggest that adequate laboratory facilities contribute not only to the implementation of practical learning activities but also to creating more effective learning environments that support students' scientific skill development.

Despite the generally positive findings, educational media showed the lowest percentage among all assessed aspects, mainly due to the limited availability of blackboards in one of the observed schools compared with the standards established by the Regulation of the Minister of National Education Number 24 of 2007. Blackboard availability remains important because it supports teachers in explaining experimental procedures and scientific concepts during practical activities (Meita, 2018). However, several schools had gradually shifted toward digital learning media such as PowerPoint presentations and digital visualisations, reflecting the integration of technology into laboratory-based learning. Similar studies also reported that limitations in laboratory support systems and management may affect the effectiveness of laboratory utilisation and practical learning implementation (Rahmah et al., 2021; Santoso et al., 2024). Therefore, maintaining both conventional and digital instructional media remains important to support effective biology practical learning activities (Suyantri et al., 2024).

Overall, the findings indicate that public senior high schools in Malang City generally possessed adequate laboratory facilities and management systems to support biology practical learning activities. Nevertheless, improvements in safety management, waste disposal procedures, and laboratory maintenance are still necessary to optimise

laboratory utilisation and ensure sustainable laboratory safety practices.

CONCLUSION

The results of this study showed that the management of biology laboratories in public senior high schools in Malang City was generally rated very good, with an average score of 87.69%. The completeness of laboratory facilities and materials was also categorised as *very complete*, with an average percentage of 89.20%. Most schools had implemented proper laboratory management practices related to material procurement, storage, maintenance, and laboratory safety. In addition, the availability of laboratory equipment and supporting facilities generally met the standards required for biology practical learning activities. As the evaluation was based on senior high school laboratory standards (Permendiknas No. 24 of 2007), the findings primarily reflect the adequacy of facilities for secondary education. While some facilities may support basic practical activities in higher education, their suitability for vocational, diploma, or university laboratories requires further evaluation against the relevant standards and requirements.

However, several aspects still require improvement, particularly laboratory safety management, hazardous waste disposal procedures, and laboratory infrastructure maintenance. Therefore, continuous supervision, maintenance programs, and competency development for laboratory personnel are necessary to optimise laboratory utilisation and support effective biology learning activities. Future studies are recommended to examine the relationship between laboratory management and students' scientific skills, learning outcomes, or 21st-century competencies using broader research designs and larger samples.

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