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Analysis of Science Laboratory Management to Support Science Learning: A Systematic Review

Endah Febri Setiya Rini[1], Bramastia[1], Kevin Aditia[1], Fitriani[2], Predy Siswanto[1]
[1]Faculty of Teacher Training and Education, Science Education, Sebelas Maret University, Jawa Tengah, Indonesia
[2]Faculty of Mathematics and Natural Sciences Education, Physiscs Education, Pendidikan Indonesia University, Jawa Barat, Indonesia

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ABSTRACT

Purpose of the study: An Merdeka curriculum requires students to be able to acquire scientific attitudes and process skills in science learning. Laboratory management is very important in supporting science learning. This research aims to analyze the management of science laboratories to support science learning.

Methodology: This type of research is qualitative research using a systematic literature review method. The population in this study was 60 articles originating from Google Scholar with publications from 2018 to 2023 which were then filtered again and a sample of 18 articles was obtained. The data analysis technique uses the matrix method.

Main Findings: Based on the results of a systematic literature review analysis, it is known that laboratory management in several schools has factors inhibiting laboratory management, such as the unavailability of laboratory personnel and technicians, multifunctional laboratory space, allocation of time for laboratory use, and lack of infrastructure in science laboratories. The conclusion in this research is that based on a review of literature studies, it is known that in the management of science laboratories in junior high schools, in some literature there are still inhibiting factors in its management.

Novelty/Originality of this study: The novelty in this research is the existence of a literature study which discusses the management of science laboratories in supporting science learning.

Corresponding Author:
Endah Febri Setiya Rini,
Faculty of Teacher Training and Education, Science Education, Sebelas Maret University,
Ir Sutami road No.36, Surakarta, Central Java, 57126, Indonesia
Email: endahfebrisetiyarini@student.uns.ac.id

1. INTRODUCTION

Merdeka curriculum was launched by the Minister of Education, Culture, Research and Technology, Nadiem Makarim, as a form of evaluation of improvements to the 2013 Curriculum [1], [2]. With an merdeka curriculum, it is hoped that students can develop according to their potential and abilities because students receive critical, quality, expressive, applicable, varied and progressive learning [3]–[5]. Science learning outcomes in the merdeka curriculum emphasize process skills.

Science process skills are skills that are needed in the 21st century. Science process skills help students to develop a sense of responsibility in learning and increase the importance of research methods in the learning process [6], [7]. Science process skills aim to enable students to be more active in understanding and mastering the series they carry out, such as observing, grouping/classifying, interpreting, predicting, hypothesizing, making

experimental/research plans, and communicating [8]–[11]. Science process skills can be acquired by carrying out practical activities [12]–[14].

Practical activities cannot be separated from science learning. Practical activities can improve students' skills in experiments [15], [16]. Practical activities are learning activities in the form of observing experiments, testing, and discoveries related to laboratories that can develop basic experimental skills [17]. Practical activities are students' direct experience in gaining knowledge through experiments [18]–[21]. Practical activities are sometimes rarely carried out because the laboratory equipment owned by schools is still limited so that students do not have the expected knowledge and experience [22], [23]. Practical activities are important to carry out because, with direct learning experiences, students can improve their understanding of concepts and practice science process skills and laboratory skills [24], [25]. Practical activities will run well if there is good laboratory management.

The laboratory is a learning tool to support practical science learning activities. Laboratories have been given a central and special role in science education, and science educators have stated that many benefits in learning are derived from their use [26]. The laboratory must be equipped with various infrastructure for experimental needs [27]. To optimize the role of the laboratory, it needs to be supported by a good laboratory management system [28]. Management of this laboratory includes aspects of planning, organizing, implementing and evaluating as well as several layout requirements, completeness of facilities and administration that must be met [29].

Research [30] shows that it is important to understand laboratory management and a strong commitment to the role of laboratories as producers of reliable and trustworthy data. Research [31] examines how to manage laboratories for science learning in schools. Research [32] examined science laboratory activities and their implementation. Based on several studies, these have examined science laboratory activities but have not discussed the science laboratory management system and the obstacles that often occur in science laboratories.

The aim of this research is to analyze the management of science laboratories to support science learning in schools. The questions asked in this research are 1). How was the management of science laboratories in schools in previous research?; 2). What are the inhibiting factors or obstacles that occur in science laboratory management?

2. RESEARCH METHOD

The type of research used in this research is qualitative research with a systematic literature review method. A systematic literature review is a literature review that follows standard rules in identifying and synthesizing all relevant studies and providing an assessment of what is known about the study topic [33]–[35]. The choice of the type of systematic literature review research was based on being able to analyze the management of science laboratories based on previous research studies.

The population in this study was selected based on article criteria and keywords that correspond to the variables in this study. The population in this study was 60 articles in Indonesian and English which were obtained through article searches using the Google Scholar database in the publication period from 2018 to 2023. The sampling technique in this research was using a purposive sampling technique. Purposive sampling technique is a sampling technique with criteria and considerations from the researcher [12], [13], [36], [37].The sample in this research was 18 articles.

The procedure in this research is that the researcher first determines keywords related to this research topic to be used as the main search. Second, keywords were obtained in the form of "laboratory", "laboratory management in science learning", "science laboratory management" then a literature search was carried out on Google Scholar with a publication period of 2018 to 2023. Third, the selected articles were reviewed by reading the title and abstract, and found 60 suitable articles. Fourth, the articles were filtered again by reading the entire contents of the articles, and we obtained 18 articles that could be used as references. The data analysis technique used in this research is synthetic matrices. Synthesis matrix is a technique for processing literature study data by interpreting it in tabular form [38].

3. RESULTS AND DISCUSSION

The results of the literature study regarding management laboratories were analyzed using the table matrix shown in Table 1.

Table 1. Matrix article

Tittle	Authors (Years)	Findings
Manajemen Laboratorium Dalam Upaya Mewujudkan Prestasi Belajar IPA [Laboratory Management in Efforts to Achieve	[39]	The results of this research indicate that the management of the science laboratory from the aspects of planning, organization,

Tittle	Authors (Years)	Findings
Achievement Study science]		implementation and supervision in an effort to realize science learning achievement at SMPN 3 Pengasih Kulon Progo is good. Supporting factors in the management of the science laboratory at SMPN 3 Pengasih Kulon Progo include: availability of infrastructure, availability of competent teaching staff, availability of natural surroundings as learning objects and resources, availability of adequate funds and support from parents/guardians. Factors inhibiting science laboratory management include: unavailability of laboratory staff, allocation of time for laboratory use and diversity of student input. Students can achieve science learning achievement with laboratory management at SMPN 3 Pengasih Kulon Progo.
Analisis Studi Kelayakan Laboratorium Ilmu Pengetahuan Alam di SMPN 2 Tempurejo Jember [Feasibility Study Analysis of Natural Sciences Laboratory at SMPN 2 Tempurejo Jember]	[40]	The research results show that with a multifunctional room, all laboratory activities can be carried out properly, safely and in an orderly manner with existing procedures, and can be said to be suitable for laboratory use.
Manajemen laboratorium dalam upaya meningkatkan mutu pembelajaran [Laboratory management in an effort to improve the quality of learning]	[41]	Management planning for laboratory facilities and infrastructure in improving the quality of learning in schools must be carried out by looking at existing needs, both office needs and learning needs. Implementation of management of laboratory facilities and infrastructure in improving the quality of learning in schools includes procurement, inventory, storage, arrangement, use and maintenance. Evaluation of the management of laboratory facilities and infrastructure in improving the quality of learning in schools must be carried out at the end of the semester by looking and checking whether there is anything that needs improvement or not.
Analisis Pengelolaan Laboratorium IPA SMP Negeri 1 Sukodono Lumajang [Analysis of Science Laboratory Management at SMP Negeri 1 Sukodono Lumajang]	[42]	The research results show that the school has 2 laboratories close to each other, supported by complete equipment and materials, a flexible schedule for laboratory use, the source of funds comes from BOS funds, and there are SOPs. However, management is considered less than optimal, due to the absence of laboratory assistants and technicians to manage the laboratory, resulting in the science teacher having to do everything.
Sistem Pengelolaan (Perencanaan, Pelaksanaan, Evaluasi) Laboratorium IPA SMP Negeri di Ponorogo [Management System (Planning, Implementation, Evaluation) of State Middle School Science Laboratory in Ponorogo]	[43]	The research results show that the laboratory management system at the four State Middle Schools in Ponorogo is in the good category. In terms of planning, namely related to layout, room layout, equipment, materials and administration, it is in accordance with standard laboratory management guidelines. Based on the implementation of the practicum, the four schools have carried out the practicum according to the schedule and routine according to the semester program. Three of the four schools studied have used

Tittle	Authors (Years)	Findings
		laboratories according to their function, not used for other things that are not related to the implementation of practicums. The work guide used in the laboratory is still not optimal in achieving science learning objectives. In terms of evaluation and monitoring, the four state schools studied routinely carry out laboratory evaluations and then carry out monitoring every year.
Pengelolaan Laboratorium Ilmu Pegetahuan Alam SMP Negeri 2 Singaraja [Management of the Natural Sciences Laboratory at SMP Negeri 2 Singaraja]	[44]	The research results show the following. (1) planning for the science laboratory work program has not been implemented properly; (2) the organization carried out is still not in accordance with laboratory management regulations; (3) the implementation of the science laboratory work program is still not running intensively; (4) monitoring and evaluation is carried out internally; (5) factors that influence the management of the science laboratory at SMPN 2 Singaraja, namely laboratory assistants, students, time, and limited equipment and materials.
Pelatihan Penggunaan Alat dan Bahan Praktikum IPA untuk Guru IPA Se-Kabupaten Kubu Raya [Training on the Use of Science Practical Tools and Materials for Science Teachers throughout Kubu Raya Regency]	[45]	Training and assistance in using the Science KIT is really needed by all teachers, especially science teachers, whether elementary, middle school or high school.
Analisis Kesiapan dan Evaluasi Pengelolaan Laboratorium IPA berbasis Teknologi di Eraa Revolusi Industri 4.0 [Analysis of Readiness and Evaluation of Technology-based Science Laboratory Management in the Era of Industrial Revolution 4.0]	[46]	The results of the analysis of Science Laboratory Readiness based on technology criteria have not reached 50%, meaning they are not ready. The highest evaluation of the implementation of the Science Laboratory was obtained by public schools in the city area at 85% in the very good category, while the lowest score was obtained by private schools in the village area at 66.25% in the adequate category, whereas The availability of science laboratory facilities and infrastructure meets the standards of Minister of National Education Regulation No. 24 of 2007 at 78.3% in the good category. There is a need for an educational research policy to be able to overcome the problems of science laboratories in the era of the industrial revolution 4.0 in the form of revitalizing the management of science laboratories using cyber systems and technology-based virtual laboratories.
Pengelolaan Laboratorium Ipa Smp Negeri 2 Muara Rupit Kabupaten Musi Rawas Utara Tahun 2020 [Management of the Science Laboratory at Secondary School 2 Muara Rupit, North Musi Rawas Regency in 2020]	[25]	Science laboratory planning includes the procurement of science laboratory equipment/materials carried out by the science laboratory coordinator and science teachers through needs analysis based on a priority scale adjusted to existing funds. The plan for using the science laboratory in science learning is less detailed than a daily schedule, but there is only a monthly schedule. Regulations on the use of the science laboratory include: (a) rules for the use of the science laboratory, (b) preparation of science tools/materials, (c) storage of science tools/materials, (d)

Tittle	Authors (Years)	Findings
		maintenance/maintenance of the science laboratory carried out by the science laboratory coordinator who stated in writing in the laboratory use regulations. (3) The supervision carried out by the school principal is still limited to knowing the implementation of teaching and learning activities in the laboratory, and does not yet lead to the science laboratory management process. Meanwhile, the evaluation of science laboratory management carried out by the science laboratory coordinator is only limited to evaluating the suitability of equipment and the availability of science materials, the results of which are used as a reference in procuring equipment in the following year.
Analisis Standarisasi Sarana, Prasarana dan Tenaga Laboratorium IPA MTs Negeri 8 Jember [Analysis of Standardization of Facilities, Infrastructure and Science Laboratory Personnel at MTs Negeri 8 Jember]	[47]	The research results showed that the facilities and infrastructure in the MTs Negeri 8 Jember laboratory were around 75% available due to several practical equipment being lost and damaged. Meanwhile, the laboratory staff at MTs Negeri 8 Jember only has a laboratory head, while the duties of laboratory assistants and technicians are replaced by laboratory heads and science teachers. The solution to overcome these obstacles is that the principal together with the school committee and the laboratory work together to propose laboratory needs in the form of equipment and materials as well as laboratory personnel.
The effect of laboratory knowledge, teaching practice experience, and work motivation on laboratory management	[48]	The research results show that there is a significant influence of laboratory knowledge on laboratory management, with a calculated f of 15.597. There is a significant influence of teaching practice on laboratory management experience with a count of 5.119; there is a significant influence of work motivation on laboratory management with a calculated f of 17.207; and there is a significant influence of laboratory knowledge, practical teaching experience, and motivation for laboratory management work on Yogyakarta City School teachers with a coefficient of determination of 50.4% simultaneously influencing laboratory management.
Analysis of Chemical Laboratory Management at SMAN 55 Jakarta	[49]	The results of the research are: 1) Laboratory work program planning has been prepared and standardized by the head of the laboratory, 2) Organizing the laboratory structurally already exists, 3) Organization by the principal involving all parties involved in laboratory management, 4) The program implementation in accordance with the work program plan, 5) Monitoring and evaluation In principle, it still has to be done intensively. In other words, laboratory management has has been well organized.
Basic Laboratory Management Training for Institutions	[30]	Understand laboratory management and the importance of a strong commitment regarding the role of

Tittle	Authors (Years)	Findings
		laboratories as reliable and trusted "data producers". Have thorough knowledge of human resource management, equipment, chemicals and waste handling. Able to coordinate and motivate laboratory staff and personnel to work together, seriously and dedicatedly. Have the ability to manage a laboratory in a clean, neat and safe manner. Understand the latest laboratory management systems. Understand the principles of occupational safety and health in the laboratory. Able to compile documents and record laboratory management activities based on the latest laboratory management system. Able to manage laboratory equipment, materials and methods according to the scope of technical guidance.
How to Manage an Effective Laboratory for Science Learning in Schools?	[31]	First, improving the management and inventory of laboratory equipment and materials as well as creating SOPs for effective practices in optimizing the role of science laboratories in supporting the learning process; Second, the use of SOP practices according to the learning schedule is quite efficient in saving time, energy and costs. Based on the research results, it is recommended that laboratories can be optimal in supporting learning, laboratory management must be carried out with SOPs, and inventory of equipment and materials must be good.
Analysis of Laboratory Management Capability and Literacy Level of Science Physics Teacher	[50]	Implementation of physics practicum activities in schools are still relatively lacking in scientific literacy capabilities teachers in managing the laboratory are not optimal.
The Effectiveness of Science Laboratory Management at Junior High School	[51]	Overall, the results obtained are very good category, standard value A. However, in reality there are still several problems in the laboratory Its management causes problems in several indicators such as completeness of equipment and equipment inventory and the main material and problems occur in organizational and administrative indicators with an overall average the result was 49.82% below the expected standard in the bad category. So it needs to be re-evaluated and improve administrative and organizational management which is often overlooked by school laboratories management so that special attention can be given to further improvements to obtain superior effective results in the future
Improving The Capability Of School Science Laboratory Managers Through School Supervision Assistance In Cluster I Of Baguala District, Ambon City	[52]	Assistance from school supervisors can improve the ability of science laboratory managers in these four areas school.
Development of Laboratory Management Based on Local Bali Wisdom to Improve the Quality of Services in Laboratory	[53]	Balinese local wisdom related to laboratory management, the laboratory management model is based on Balinese local wisdom to improve the quality of laboratory services, the laboratory

Tittle	Authors (Years)	Findings
		management model developed is very effective, the model can be implemented, and the student response to the laboratory management model based on Balinese local wisdom is very positive.

Based on Table 1, it shows that science laboratory management involves the aspects of planning, organizing, implementing, and supervising. Supporting factors in science laboratory management include the availability of infrastructure, the availability of competent teaching staff, the availability of natural surroundings as learning objects and resources, the availability of adequate funds, and support from parents and guardians. Factors inhibiting science laboratory management include the unavailability of laboratory staff, the allocation of time for laboratory use, the multifunction of the laboratory, limited equipment and practical materials, and the diversity of student input. On average, in the schools studied based on the literature, many of them do not have laboratory assistants and technicians to manage laboratories, so it makes science teachers do it all. The solution to overcome these obstacles is that the principal, together with the school committee and the laboratory, work together to propose laboratory needs in the form of equipment and materials, as well as laboratory personnel.

Based on the literature review, it shows that there is already laboratory management carried out by the school. In the planning aspect, laboratory work program planning has been prepared and standardized by the head of the laboratory, procurement of science laboratory equipment/materials is carried out by the science laboratory coordinator and science teachers through needs analysis based on a priority scale adjusted to existing funds. The plan for using the science laboratory in science learning is less detailed than the daily schedule, but there is only a monthly schedule. In terms of planning, namely related to layout, room layout, equipment, materials and administration, it is in accordance with standard laboratory management guidelines. In the aspect of organization, there has been organization in the laboratory but the lack of human resources and the presence of multiple science teachers who double as laboratory heads and several schools that do not have laboratory assistants create obstacles in managing the laboratory, as well as a lack of cooperation between groups of people who use the laboratory. In this aspect, assistance and guidance is needed regarding the importance of playing a joint role in laboratory management and complying with laboratory regulations as well as cooperation in cleaning, storing and maintaining laboratory equipment. In the implementation aspect, every time you are going to carry out a practicum, you should fill out a request and borrow equipment form which is then submitted to the laboratory assistant at least a week before the implementation, so that the laboratory assistant can prepare and check. . whether the necessary equipment and materials are available or not. After the laboratory activity is completed, the teacher should fill in a diary to find out what happened during the laboratory activity and for supervision purposes. In this aspect, the tools and materials that have been used are immediately cleaned and stored back in their original place. In the supervision aspect, the school has implemented supervision, namely internally and externally through the school principal and representatives of the education office.

Management planning for laboratory facilities and infrastructure in improving the quality of learning in schools must be carried out by looking at existing needs, both office needs and learning needs. Implementation of management of laboratory facilities and infrastructure in improving the quality of learning in schools includes procurement, inventory, storage, arrangement, use and maintenance. Evaluation of the management of laboratory facilities and infrastructure in improving the quality of learning in schools must be carried out at the end of the semester by looking and checking whether there is anything that needs improvement or not. Training and assistance in using the Science KIT is really needed by all teachers, especially science teachers, whether elementary, middle school or high school.

Science learning outcomes in the kurikulum merdeka emphasize inquiry learning based on science process skills [54]. Science process skills in science learning are very important to be able to discover knowledge through experiments that use scientific steps. In carrying out experimental activities, facilities in the form of a laboratory are required. A laboratory is a place for teaching and learning through practical methods that can produce learning experiences where students interact with various tools and materials to observe symptoms that can be observed directly. Laboratories are very important in science learning to support learning and discovery in the laboratory. Learning laboratories are used to prove a theory, while research laboratories are used to examine symptoms or facts, theories and laws [55]. The benefits of students studying in the laboratory are that students can study facts, symptoms, formulate concepts, legal principles and so on, gain cognitive knowledge and work skills, can apply this knowledge and skills to new situations, and gain a scientific attitude. In order for the laboratory to function according to its function, the laboratory must be in good condition. A good laboratory is influenced by good laboratory management as well. Laboratory management has several aspects, namely planning, structuring, administration, security, maintenance and supervision [41].

Suggestions for schools in laboratory management are that in planning it is best to adjust the data to the need for tools and materials to support practical activities so that tools and materials are not limited and do not hinder science learning through practicums. Laboratories need better planning by not using science laboratories

as multifunctional spaces. In the organizational aspect, there is a need for a better laboratory organizational structure, namely that teachers are not appointed as chairmen or laboratory assistants and the need for cooperation between laboratory users to comply with laboratory SOPs so that the laboratory can function well in terms of maintenance and cleanliness of laboratory equipment and space. Suggestions for future researchers are to research science laboratory management at elementary school, secondary school, high school and University levels directly in the field. And can provide innovations that support laboratory management systems.

4. CONCLUSION

Based on the results and discussion, it can be concluded that laboratory management needs to be carried out so that it can support science learning well. Laboratory management already exists in schools, the obstacles that occur are in the planning aspect it is necessary to provide sufficient infrastructure and the laboratory not to be used as a multifunctional space. In the organizational aspect, the inhibiting factors that occur are the unavailability of laboratory personnel and the lack of cooperation between laboratory users in complying with laboratory SOPs. In the implementation aspect, there is a need for coordination between the teacher and the laboratory coordinator in terms of laboratory use and use of practical equipment and materials.

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