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# Science and Technology Reciprocity in Educational Laboratory Systems Intermediate in Kota Sungai Penuh

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**Abstract:** The determination of science and technology is a prerequisite for the development of modern laboratory systems. This study examines the laboratory management system in the interrelationship between science and technology. Qualitative evaluation methods are used to accommodate research questions related to the comparison of objectives and realities of laboratory systems. The focus of research lies in the management system and management paradigm of science and technology. The study was conducted in all public high schools in Kota Sungai Penuh, Jambi. The study used naturalistic observation to observe laboratory conditions and semi-structured interviews from laboratory managers, educators involved in the laboratory and students. Research bias is minimized by comparing observations and some interview results. The results showed that there is a gap in laboratory management of schools in newly developing cities. This slice of science and technology in the laboratory management system is influenced by past views, present feelings and future assumptions from laboratory managers, parties and educators involved. Then policy and policy realization magnify the gap created. The gap can be addressed by using virtual labs.

**Keywords**: Laboratory Evaluation, Laboratory Management, Science, Technology

## A. Introduction

The determination of science and technology is a prerequisite for the development of modern laboratory systems (Lindawati et al., 2021). Advances in science and technology have provided a solid foundation for the development of efficient and sophisticated laboratories. Technology has enabled the development of laboratory equipment that is more precise, sensitive, and can produce accurate data (El Kharki et al., 2021). Science and technology synergistically complement each other and encourage laboratory progress towards achieving superior and applicable research results (Klein, 2008). With determination in applying science and technology in the laboratory, we can continue to expand the boundaries of knowledge and produce new breakthroughs that contribute to the development of science and technology in the future.

Kota Sungai Penuh, as part of Jambi Province, Indonesia, has several high schools (SMA) that offer science education, including biology, to its students. The laboratory becomes a key component in the process this teaching and learning, where students can conduct experiments and direct observations to understand concepts more deeply (Adilah et al., 2021; Asiyai, 2012). Laboratories facilitate empirical knowledge-based learning that contributes significantly to the development of students' conceptual understanding and science process skills. However, effective and efficient laboratory management and management is often a significant challenge for schools (Riswanto et al., 2019).

The existence of laboratories in schools is very important in supporting biology teaching and learning activities (Mahanani et al., 2020), because there are several materials that in understanding it need to make observations or experiments in the laboratory. In addition, in Government Regulation Number 32 of 2013, it is explained that every education unit must have infrastructure that can support an orderly and continuous learning process, one of which is laboratory space.

The laboratory will be good if the management in it is also good (Mahanani et al., 2020). The existence of laboratories in schools is very important in supporting biology teaching and learning activities because there are several materials that in understanding it need to make observations or experiments in the laboratory. In addition, in Government Regulation Number 32 of 2013, it is explained that every education unit must have infrastructure that can support an orderly and continuous learning process, one of which is laboratory space.

The laboratory will be good if the management in it is also good. Management is the art or science of organizing resources, including people, money, materials, and information, to achieve organizational or project goals effectively and efficiently. This process involves a variety of activities, including planning, organizing, leadership, and controlling (Chenhall & Euske, 2007).

In recent years, many schools have faced obstacles in carrying out activities in laboratories, especially biology laboratories. The rapid development of technology and science, biological laboratories are required to continue to adapt and be updated in the era of learning 4.0 (Klein, 2008; Wiedner & Schaeffer, 2020). The concept of learning 4.0 integrates digital technology and artificial intelligence into education. Therefore, good laboratory management is key in facing this challenge (McKim &; Saucier, 2011; Yao et al., 2010). The efforts needed include the procurement of the latest laboratory equipment in accordance with technological developments, training and development of laboratory staff in the use of technology, and curriculum renewal that integrates learning concepts 4.0 (Administrare et al., 2022; Blaine, 2012). With effective laboratory management, it is expected that science education in Kota

Sungai Penuh can adopt a 4.0 learning approach, provide relevant practical experience, and support the development of students' skills in the field of biology using advanced technology.

Based on the results of initial observations in several high schools in Kota Sungai Penuh, it can be seen that there are schools that already have laboratories but have never been used in the practicum process. Some have physics, chemistry, and biology laboratories, the rooms are still combined. There are also schools whose laboratories are not maintained and used as a storage place for practicum equipment and even used as a storage warehouse for sports equipment at school. Based on the observations of researchers, all labors in Kota Sungai Penuh already have a Head of Labor. However, the unclear head of labor in all schools caused laboratory management to not run well. This is evidenced when teachers want to do practicum, often teachers in the field of study directly prepare the tools and materials needed during practicum and even tools and materials are often not available at school, causing teachers to be lazy to do practicum for the future. These things can happen because there are no special officers such as laboratory workers in arranging the tools and materials needed during practicum. This shows that laboratory management has not been going well.

Based on the above problems, researchers can conclude the problems that occur in high schools in Kota Sungai Penuh: First, is the problem of inadequate human resources. This causes a lack of competent and professional teaching staff in managing biological laboratories. Second, the problem of inadequate facilities and equipment. Inadequate laboratory facilities and equipment can hinder the teaching and learning process and make students less motivated to follow lessons (Arshad et al., 2018; Owoeye & Yara, 2011). Third, security and safety issues. Security and safety in biological laboratories are very important (Blaine, 2012), because many chemicals and biological materials are dangerous. However, lack of good supervision and control can lead to accidents and endanger students. Fourth, the problem of planning and evaluation. Poor planning and evaluation can cause not to achieve goals and objectives in the management of biological laboratories.

Therefore, it is important to analyze the management of biological laboratories in high schools in Kota Sungai Penuh. The application of technology in secondary education laboratory systems is becoming essential to optimize students' learning experiences and prepare them for the demands of an increasingly digital and connected age (Blaine, 2012; Reeves et al., 2004). This analysis is expected to identify challenges and weaknesses in the current management of biological laboratories, as well as provide recommendations for improvement and improvement. In addition, the analysis will also provide a better picture of how schools in Kota Sungai Penuh manage and utilize their biology labs in support of science education.

Thus, the management of the biology laboratory at SMA Sekota Sungai Full needs to be improved so that the teaching and learning process can take place properly and in accordance with the goals and objectives of biology education. Based on these problems and the absence of research on the management picture of the biology laboratory of SMA in Kota Sungai Penuh, the researcher conducted a study entitled "Science and Technology Reciprocity in the Secondary Education Laboratory System in Sungai Penuh City".

## B. Methods

The research method used is qualitative evaluation research. This method was chosen because it provides an in-depth and detailed overview of the management problems of biological laboratories in the school. This study used observation, interview, and documentation techniques as data sources. Observations were made to determine the current conditions and situation in the management of the biological laboratory at SMA Sekota Sungai Penuh. Interviews were conducted with relevant parties such as biology teachers, principals, and laboratory staff to find out the problems that occurred and obtain information about efforts that have been made to overcome the problems. Documentation is carried out to obtain secondary data such as financial statements, evaluation reports, and documents related to biological laboratory management. By using qualitative evaluation methods, researchers can obtain quite in-depth and detailed data on biological laboratory management problems at SMA Sekota Sungai Penuh, so as to produce appropriate and appropriate solutions to overcome these problems.

## C. Results and Discussion

### Planning

A good management activity certainly begins with a careful and good planning. Planning is done to avoid unwanted mistakes and failures. Planning of educational facilities and infrastructure including laboratories is a process of thinking about and determining school facilities procurement programs, both in the form of educational facilities and infrastructure in the future to achieve certain goals. Laboratory planning in schools is carried out by looking at the needs of goods and budgets. This planning can be done at the end of each semester through a coordination meeting between the head of the laboratory, infrastructure representatives, and school principals (Marlina SMKN & Raya Pasar Ketahun, Kec Ketahun, North Bengkulu Regency, n.d.). The planning indicators can be seen in the following table:

**Table 1. Laboratory Room of Several Public High Schools in Sungai Penuh City**

| Laboratory Room | School/Accreditation | | | | |
|---|---|---|---|---|---|
| | SMAN 1 Sungai Penuh /A | SMAN 2 Sungai Penuh /A | SMAN 3 Sungai Penuh /A | SMAN 4 Sungai Penuh /A | SMAN 5 Sungai Penuh /B |
| Laboratory | IPA | IPA | Biology | IPA | IPA |
| Capacity (students) | 30 | 30 | 30 | 36 | 20 |
| Area (pxd) m | (10x11) | (10x11) | (9x8) | (10x8) | (7x8) |
| Storage and preparation space (pxl) m | 3x6 | (3x6) | (2,5x4) | (3x6) | - |
| Ratio/learners (m2/learner) | 3 | 3 | 2,4 | 3 | 2 |

From table 1 above, it can be seen that only one school has a biology laboratory room that does not join the physics laboratory and chemistry laboratory. In PERMENDIKNAS Number 24 of 2007 it has been explained that the standard of laboratory facilities at the high school / MA education level is more complex than in junior high school/ MTS so that laboratory rooms are classified based on their disciplines. The labs at River City High School are full of simpler and limited infrastructure. On the other hand, laboratories in developing cities are usually equipped with better and adequate infrastructure to support practicum activities. The results of the analysis of the completeness of practicum tools and materials that have been carried out from the observations obtained can be seen in Table 2 below.

**Table 2. Completeness of Biology Practicum Tools and Materials for Several Sungai Penuh City High Schools**

| School/Accreditation | Completeness Percentage (%) | Criterion |
|---|---|---|
| SMAN 1 Sungai Penuh | 56,89 | Incomplete |
| SMAN 2 Sungai Penuh | 55,01 | Incomplete |
| SMAN 3 Sungai Penuh | 52,50 | Incomplete |
| SMAN 4 Sungai Penuh | 53,15 | Incomplete |
| SMAN 5 Sungai Penuh | 36,75 | Incomplete |

From the observations, it shows that biological laboratory equipment/ facilities have not met the standards of infrastructure facilities that must be owned in accordance with Permendiknas No. 24 of 2007 concerning standards of laboratory facilities and infrastructure. This is because the budget for purchasing equipment and replacing damaged equipment budgeted by the school is still too small to be able to meet these standards. Therefore, there is a lack of laboratory equipment/ facilities needed in learning biology, and this problem will certainly have an impact on the non-optimal process of learning biology. In developing cities, these resources may be more abundant and more readily available. Laboratories in developing cities are also more

likely to get funding and support from the government or other organizations to improve teaching facilities and quality. The administrative equipment of the biology laboratory in five high schools in Kota Sungai Penuh can be seen in table 3 below.

**Table 3. Biology Laboratory Administration**

| School/Accreditation | Administration |
|---|---|
| SMAN 1 Sungai Penuh | Equipment and material inventory books, laboratory usage data, tool and material borrowing data, equipment and materials receipt lists. list of damaged tools and materials, request form for tools and materials, stock card, repair card, list of proposed repair/procurement of tools laboratory. |
| SMAN 2 Sungai Penuh | Equipment and material inventory book, laboratory usage data (diary), equipment and material loan data, list of equipment and material receipts, list of damaged tools and materials, stock card, repair card, list of proposed repair/procurement of laboratory equipment. |
| SMAN 3 Sungai Penuh | Inventory books of tools and materials, laboratory usage data, lists acceptance of tools and materials. |
| SMAN 4 Sungai Penuh | Inventory books of tools and materials, laboratory usage data, lists acceptance of tools and materials. |
| SMAN 5 Sungai Penuh | Equipment and material inventory books, laboratory usage data, data borrowing of tools and materials, list of receipt of tools and materials. |

Based on the data above, it can be concluded that SMA in Kota Sungai Penuh has carried out Administration of laboratory equipment and materials in the laboratory by recording the number of tools and materials in the laboratory with the aim of facilitating examination. However, this inventory is only recorded in a book. Schools should conduct inventories by utilizing technology, for example computerized as a master list. Laboratory administration involves a series of tasks and procedures that need to be followed to maintain the operationality and efficiency of the laboratory (Bozeman & Scott, 1992). Laboratory operationality and efficiency are the responsibility of laboratory technicians (Tansey, 2008), including in laboratory administration. Administration can basically be done by people who have received special education such as teachers or people who have been specially trained to become laboratory officers such as laboratory technicians or laboratory assistants.

**Organizing**

Five high schools in Kota Sungai Penuh that have been studied, the biology laboratory does not yet have laboratories and technicians. All biological laboratory activities experience serious problems, because all work that should be done by technicians and laboratories but is prepared by teachers in the field of study. Laboratory managers usually have someone who helps, namely a laboratory technician whose job is to help prepare materials and practicum equipment to be

used, maintenance and storage of tools and materials, and periodically check tools and materials in the laboratory. So that no more expired materials are found.

In addition, researchers also found that only one school has labor coats, namely at SMAN 2 Sungai Full which has 100 labor coats, but labor coats are often not used during lab work because the storage of labor suits that should not make many labor coats moldy and damp. Labor suits should be Personal Protective Equipment (ADP) that should be worn during practicum (Aruma Pertiwi et al., 2016). In order to avoid unwanted possibilities.

**Implementation**

The implementation of laboratory activities (practicum) in five high schools in Kota Sungai Penuh that have been studied is more often carried out according to the schedule that has been made. However, not all laboratory activities (practicum) that have been scheduled in accordance with the semester/annual program can be carried out.

**Supervision**

The supervision carried out by the head of the laboratory in the five high schools in Kota Sungai Penuh studied has not been maximized, because the head of the laboratory concurrently serves as a teacher in the field of biology or chemistry and the absence of technicians and laboratories. School facilities including laboratories should be checked regularly and decentralized (Asiyai, 2012). The following is how the management of the Biology Laboratory in five Sungai Full State High Schools in terms of planning, organizing, implementing and supervising.

**Tabel 4. Biology Laboratory Management in Five High Schools Sungai Penuh**

| Indicator | Accreditaion of School | | | | |
|---|---|---|---|---|---|
| | SMAN 1 Sungai Penuh /A | SMAN 2 Sungai Penuh /A | SMAN 3 Sungai Penuh /A | SMAN 4 Sungai Penuh /A | SMAN 5 Sungai Penuh /B |
| **Planning** | | | | | |
| - Infrastructure: | | | | | |
| a. Laboratory: | | | | | |
| 1. Biology | – | – | √ | – | – |
| 2. The ratio according to the minimum ratio on PERMENDIKNAS | √ | √ | √ | √ | – |
| 3. Storage and Preparation Room | √ | √ | √ | √ | – |
| b. Complete practical tools and materials | √ | – | √ | – | – |
| c. Complete laboratory facilities | – | – | – | – | – |
| d. The period for proposing laboratory tools and materials between the teacher and the head of the laboratory is the same | – | – | – | – | – |
| - A schedule for laboratory use is posted | √ | √ | – | √ | √ |
| - Laboratory funding sources: | | | | | |
| a. School self-support | – | – | – | – | – |
| b. School Committee | √ | √ | – | – | – |
| c. Government | √ | √ | √ | √ | √ |
| d. Other | – | – | – | – | – |
| - Full laboratory administration | – | – | – | – | – |
| **Organizing** | | | | | |
| - Organizational structure | √ | √ | √ | √ | √ |
| - Technician | – | – | – | – | – |
| - Laboratories | – | – | – | – | – |
| - Training/seminars | – | – | – | – | – |
| - Storage of tools and materials | | | | | |
| a. According to the group (eg: Group tools and materials are separated) | √ | – | √ | √ | – |
| b. Neatly arranged | – | – | – | – | – |
| - Laboratory regulations: | | | | | |
| a. Student | √ | √ | √ | √ | √ |
| b. Teacher | √ | √ | √ | √ | √ |
| **Implementation** | | | | | |
| - Practical activities according to schedule | √ | √ | √ | √ | √ |
| - The laboratory assistant prepares the tools and materials used for the practicum activities according | – | – | – | – | – |

| | | | | | |
|---|---|---|---|---|---|
| to the teacher's request | | | | | |
| - Students work in Groups | √ | √ | √ | √ | √ |
| - The teacher gives instructions to students | √ | √ | √ | √ | √ |
| - The teacher checked the tools and materials that were used. | √ | √ | √ | √ | √ |
| **Supervision** | | | | | |
| - The head of the laboratory controls laboratory activities every day | – | – | – | – | – |
| - The teacher supervises practicum activities | √ | √ | √ | √ | √ |
| - Kepal The head of the laboratory monitors the arrangement of laboratory items properly a laboratorium | √ | √ | √ | √ | √ |
| - The teacher communicates the obstacles that occur to the head of the laboratory | √ | √ | √ | √ | √ |

Based on the table above, it can be seen that labor management in newly developing city schools has not been carried out properly in accordance with Permendiknas No. 24 of 2007 concerning standards of laboratory facilities and infrastructure. This slice of science and technology in the laboratory management system is influenced by past views, present feelings, and future assumptions from laboratory managers, parties and educators involved. Past views reflect experiences and practices that have been carried out in previous laboratory management. Meanwhile, feelings now include current perceptions and evaluations of needs and challenges in laboratory planning. Future assumptions lead to expectations and projections about upcoming laboratory technology developments as well as educational goals to be achieved (Ferrero &; Piuri, 1999).

By considering these three aspects, laboratory managers, related parties, and educators can combine past experience, present assessment, and future vision in planning and implementing an effective laboratory management system. This involves the use of cutting-edge technology, innovative policies, and educational approaches relevant to the demands of the times (Ferrero &; Piuri, 1999). Thus, schools can get optimal benefits from science and technology in an effort to improve the quality of student learning in the laboratory.

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Virtual labs reduce the risk of injury or exposure to hazardous materials (Tatli &; Ayas, 2010). Students can learn and experiment safely through controlled simulations. Thus, schools can ensure that security and safety aspects in laboratories are met without any real risk. Virtual laboratories also offer flexibility in conducting experiments (Forbus et al., 1999). Students can repeat the experiment many times, vary the parameters, and see the results live. This allows them to understand scientific concepts better through interactive and exploratory. Virtual labs allow students to collaborate and share experimental results easily through online platforms (El Kharki et al., 2021; Kapilan et al., 2021). They can discuss, analyze data, and come up with conclusions virtually. It also expands opportunities to share knowledge with other schools or other educational institutions.

## D. Conclusion

There is a gap in laboratory management of schools in the newly developing city. This slice of science and technology in the laboratory management system is influenced by past views, present feelings and future assumptions from laboratory managers, parties and educators involved. Then the policy and policy realization that should be done is to use virtual laboratories to magnify the gap created.

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