Students' Level of Knowledge of Laboratory Equipment and Materials

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Abstract. Biology Laboratory is an essential variable in determining the quality of secondary school output. Sufficient laboratory equipment suitable for teaching in secondary schools helps improve students’ skills. Knowing the equipment and materials in the laboratory supports the students in the learning process in the laboratory. This study aims to identify the level of students' knowledge of laboratory equipment and materials. It used a survey method with a sample of 106 high school students from grade XI in Yogyakarta. The data were collected by testing the students’ level of knowledge of laboratory equipment and materials. Then, the data were analyzed by calculating the average percentage and grouped them into a range of category values. The results showed that the level of students' knowledge of the laboratory equipment is quite good; the level of students' knowledge of the function of laboratory equipment is good; and the level of students' knowledge of the procedure to use the laboratory equipment is good. Moreover, the level of students’ knowledge of the characteristics of laboratory materials is good and the level of students' knowledge of the group or categorization of the laboratory materials used in practices for certain subjects is poor. The low knowledge of students about laboratory equipment and materials is due to the lack of time allocation for the teacher’s explanation about the laboratory equipment and materials and the practicum guidelines used do not summarize the laboratory equipment and materials. Therefore, further research is expected to develop practicum guidelines that contain detailed information on laboratory equipment and materials.

1. Introduction

Laboratory is one of the facilities supporting learning processes of certain subjects such as biology, physics, and chemistry. According to [1], laboratory experience is a direct interaction where research skills are used together with laboratory equipment and materials for the development and interpretation of scientific knowledge. It is in line with [2] and [3]. Important components that support activities in the laboratory are laboratory equipment and chemicals used. Laboratory equipment and materials are simultaneously used to test the truth to achieve certain goals [4].

The use of equipment and chemicals can improve hand skill, operational abilities, answer questions arisen from observations, and understand abstract perceptions into concrete perception to comprehend a theory [5]. The correct use of laboratory equipment and materials will support the success of activities in the laboratory. According to [6], the success of laboratory activities for students in science
Learning can be summarized in three domains, namely to develop cognitive domain; to develop the affective domain; and to develop skills.

The causes of laboratory accidents include (1) lack of knowledge and understanding of equipment, chemicals, and procedures, (2) lack of instructions and supervision from supervisors, (3) mistakes in planning or designing experimental procedures, (4) incorrect equipment arrangement, (5) lack of proper safety, body protection, and other safety devices, (6) violations of the instructions or rules of conduct, and (7) careless in conducting experiments [7]. Some laboratory accidents are caused by students’ carelessness in using laboratory equipment which are made of glass and low understanding of the procedure to properly use the equipment. Besides, it may occur due to a lack of understanding of the characteristics of chemicals, whether they are flammable, explosive, or corrosive [8].

Laboratory equipment is a form of technological development to improve skills and it is needed to meet the challenges of the 21st century [9]. Thus, students are expected to know about the procedure to use the equipment. Besides to develop students’ skills, knowledge of equipment and chemicals in the laboratory functions to comprehend the learning theory so that practices of certain subject run well and make it easier for students to understand the theory that has been conveyed in the classroom.

Based on the elaboration above, students’ knowledge of laboratory equipment and materials is highly needed in practicum activities to avoid accidents. Therefore, the researcher formulated the following formulation of the problem:

1. What is the level of knowledge of students on biological laboratory equipment?
2. What is the level of knowledge of students on biological laboratory materials?

2. Method

2.1. Research design
The study used a quantitative descriptive survey method. The population was grade XI students of Senior High School 11 Yogyakarta, Senior High School 06 Yogyakarta, and Senior High School 08 Yogyakarta. The study was conducted on February 2, 2020. It used a purposive sampling technique as the selection of sample used certain considerations. It involved a total of 106 students.

2.2. Instrument and data collection
The instrument used in the study was a test consisting of 35 items of the knowledge of laboratory equipment and materials. The data were collected from the test results by scoring 1 for the correct answer and 0 for incorrect answers.

2.3. Data analysis technique
The data obtained from the test were then analyzed by counting the percentage with the following formula:

\[
\text{Percentage} = \frac{\text{Number of Correct Answers}}{\text{Number of samples}} \times 100\%
\]

The percentage was then grouped into a range of category values to determine the level of students’ knowledge. The results are presented in Table 1.

| Percentage       | Category     |
|------------------|--------------|
| 76%-100%         | Good         |
| 56%-75%          | Quite Good   |
| 40-55%           | Not Good     |
| \(\leq 40\%\)    | Not Good     |
3. Result and Discussion
The results concerning the level of students’ knowledge of laboratory equipment covered some aspects such as the name, the function, the procedure to use. Meanwhile, knowledge of laboratory materials covered aspects of characteristics and grouping of materials used in practicum for certain subjects. The results of the measurement are presented in Figure 1.

![Figure 1. Percentage of Level of Students’ Knowledge of Laboratory Equipment and Materials](image)

**Figure 1.** Percentage of Level of Students’ Knowledge of Laboratory Equipment and Materials

Figure 1 shows the percentage of the level of students’ knowledge based on categories. The category is used as a benchmark to determine the minimum and maximum limits of certain measurements [13]. Based on the figure above, students have a minimum limit for grouping the chemicals used in practicum activities, while the maximum limit is on the procedure to properly use the laboratory equipment. The ranges of values in the categories are presented in table 1.

Students’ knowledge of the names of laboratory equipment was obtained from a total of 15 proposed questions in the test. The students were provided with pictures of laboratory equipment and were required to write down the complete name of the equipment under each picture, for example, Test tube clamp (√), clamp (X). The questions and answers are presented in Figures 2 and 3 below:

![Figure 2. Questions about the Name of the Laboratory Equipment](image)

Figure 2. Questions about the Name of the Laboratory Equipment

![Figure 3. Students’ Answer to the Questions about the Name of the Laboratory Equipment](image)

Figure 3. Students’ Answer to the Questions about the Name of the Laboratory Equipment

Based on Figure 3, the majority of students answered the name of the laboratory equipment incorrectly with 6 correct answers and 9 incorrect answers. Students’ incorrect answers regarding the name of the laboratory equipment include; dropper (students do not mention the complete name of the laboratory instrument), clay triangle (students do not mention the complete name of the laboratory instrument), beaker (students cannot distinguish between the graduated cylinder and beaker), test tube clamp (students do not mention the complete name of the laboratory instrument), mortar and pestle (students do not mention the complete name of the laboratory instrument), blood lancet (students answer incorrectly by writing ‘balance’), stirring rods (students answer incorrectly by writing ‘thermometer’), wire gauze (students answered incorrectly by writing ‘filter’), and bunsen burner (students answered incorrectly by writing ‘busen’).
The results of the students' knowledge of the names of laboratory equipment in the form of a percentage reached 66.03% (dropper), 67.92% (slide), 98.11% (graduated cylinder), 5.66% (clay triangle), 94.33% (beaker), 56.60% (test tube clamp), 73.58% (mortar and pestle), 92.45% (test tube rack), 77.35% (dropping plate), 40.56% (lancet), 99.05% (text tube), 49.05% (stirring rod), 86.79% (petri dish), 93.39% (wire gauze), and 62.26% (bunsen burner). Therefore, it can be concluded that the students' knowledge of the names of laboratory equipment is quite good with an average percentage of 70.87%.

Students' knowledge of the function of laboratory equipment was obtained from a total of 7 questions in the test. The type of question is multiple choice so that the student could choose the most appropriate answer, for the correct answer, they received a score of 1 and a score of 0 for an incorrect answer. The students' questions and answers are presented in Figures 4 and 5 below:

**Figure 4.** Questions about the Function of the Laboratory Equipment

**Figure 5.** Students’ Answer to the Questions about the Function of the Laboratory Equipment

Based on Figure 5, the students answered 5 correct questions and 2 incorrect questions for the function of the laboratory equipment. Students give incorrect answers for the function of the wire gauze which is to distribute the heat (students writes the function to support the equipment to stand firmly) and equipment which function to store a small amount of liquid (students tend to give the incorrect answer of test tubes, the correct one is petri dish).

The results of students' knowledge of the function of laboratory equipment in the form of a percentage reached 99.05% (test tubes), 90.56% (clay triangle), 100% (graduated cylinder), 36.79% (wire gauze), 45.28% (Petri dishes), 98.11% (dropper), and 100% (thermometer). It can be concluded that the students' knowledge of the function of laboratory equipment is good with an average percentage of 81.39%.

Students' knowledge of the names and functions of laboratory equipment will help students achieve success in performing in the laboratory. It is because knowing the names and functions of the tools used during the activity in the laboratory will make it easier for students to properly carry out the procedures. In performing activities in the laboratory, the recognition of the name and function of laboratory equipment is the early skill development to conducting experiments or to improve technical skills related to the installation and use of certain equipment or experimental settings [14].

According to the difficulty level, the operation or procedure to use the laboratory equipment is divided into 3 categories, among others [15]:

1. **Equipment category 3** is equipment with difficult operation and maintenance, high risk of use, high measurement accuracy, and complex work systems that require special training to operate.

2. **Equipment category 2** is equipment with moderate operation and maintenance, moderate measurement accuracy, and less complicated operation which requires training to operate.
3. Equipment category 1 is equipment with easy operation and maintenance, low risk of use, and a simple working system that simply requires the use of a manual or guideline to operate.

Students’ knowledge of the operation or procedure to use laboratory equipment was obtained from a total of 3 questions in the test. The type of question is multiple choice so that the students only need to choose the most appropriate answer, for one correct answer, they received a score of 1 and a score of 0 for the wrong answer. The students’ questions and answers are presented in Figures 6 and 7 below:

![Figure 6. Questions about the Procedure to use the Laboratory Equipment](image1)

![Figure 7. Students’ Answer to the Questions about the Procedure to use the Laboratory Equipment](image2)

Based on Figure 7, students only answered 1 correct and 2 incorrect questions regarding the procedure to use the laboratory equipment. Students’ incorrect answers covered the procedure to use the thermometer (students answered incorrectly by writing that a thermometer can be used by dipping the thermometer and sticking it to the beaker) and the procedure to turn off the fire on a bunsen burner (students answered incorrectly by writing blowing the fire).

The results of students’ knowledge of the procedure to use the laboratory equipment in the form of a percentage reached 98.11% (waterbath), 69.81% (thermometer), and 99.05% (turning off the fire on bunsen burner). It can be concluded that students’ knowledge of the procedure to use laboratory equipment is good with an average percentage of 88.99%.

Laboratory equipment has a specific shape and procedure to operate which has to be comprehended by the students before carrying out activities in the laboratory. Knowledge of the procedure to use laboratory equipment regularly can improve students’ skills [16]. [17] argued that the use of appropriate teaching media and methods is essential for successful teaching and learning. The findings of this study are in line with [18]. Students who use laboratory equipment correctly during practicum activities will gain hands-on experience and achieve the desired goals [19]. One of the factors that hinder the implementation of laboratory activities is the students’ low understanding of practicum procedures [20] such as inappropriate use of laboratory equipment or tools [21]. Misuse of equipment is one of the causes of the inaccuracy of the obtained data and can lead to damages to the equipment [22].

Students’ knowledge of the characteristics of laboratory materials was obtained from a total of 5 questions in the test. The students were required to match the correct answer with the question with a score of 1 for the correct answer and 0 for an incorrect answer. The students’ questions and answers are presented in Figure 8 below:
Figure 8. Students’ Answer to Questions about the Characteristics of Laboratory Materials

Based on Figure 8, the results of students’ answers to the properties of laboratory materials are that students only answer 2 correct questions and 3 incorrect questions. Student incorrect answers regarding the properties of laboratory materials include; Aquades (students answered incorrectly because distilled water is not a toxic material), alcohol (students answered incorrectly because alcohol is a dangerous material) and methanol (students answered incorrectly because methanol is a poisonous material rather than flammable).

The results of students’ knowledge of the name of the laboratory tool in the percentage, namely students’ knowledge of the chemical properties of lugol 85.84%, chemical properties of HCl 93.39%, Aquades 87.73%, chemical properties of alcohol 89.62% and chemical properties of methanol 86.79% so it can be concluded that students’ knowledge of the nature of chemicals in the laboratory is good with an average percentage of 88.67%.

Based on Figure 8, students only answered 2 correct questions and 3 incorrect questions for the characteristics of laboratory materials. Students’ incorrect answers covered distilled water (students answer incorrectly, the correct answer is that distilled water is not a toxic material), alcohol (answer incorrectly, the correct answer is that alcohol is a dangerous material), and methanol (students answer incorrectly, the correct answer is that methanol is a poisonous substance rather than flammable).

The results of the students’ knowledge of the characteristics of laboratory materials in the form of a percentage reached 85.84% (Lugol), 93.39% (HCl), 87.73% (distilled water), 89.62% (alcohol), and 86.79% (methanol). It can be concluded that the students’ knowledge of the characteristics of chemicals in the laboratory is good with an average percentage of 88.67%.

Students’ good knowledge of the characteristics of chemicals will help them make their environment remain clean, healthy, and minimize accidents in the laboratory. It is because the characteristics of chemicals in the laboratory are varied, such as methanol as poisonous chemicals, alcohol as flammable chemicals, and HCl as a corrosive chemical [23]. Even though each bottle of chemicals is equipped with a certain hazard symbol, it would be better if students understand it. Besides the characteristics of the chemicals, the working principle for the use of chemicals can also minimize accidents in the laboratory [24]. Knowing the characteristics of chemicals well can help activities in the laboratory run smoothly.

According to [20] [25], chemicals are one of the inhibiting factors in the implementation of practicum activities [26]. Some of the main findings of the study relate to the prospective science teacher’s view of laboratory accidents due to lack of knowledge of laboratory and chemical use techniques [24], poor chemical storage and treatment, or errors resulting from improper handling or application of practicum procedures [21]. The reasons for this accident were due to ignorance or misunderstanding of the characteristics of the chemicals, not knowing how to intervene for spilled chemicals, carelessness during the experiment, and not knowing or having no professional response to experimental hazards [27].

Students’ knowledge of the grouping of laboratory materials for practicum activities was obtained from a total of 5 questions in the test. The students were provided with pictures of laboratory materials used for certain practicum activities. They were required to group the materials for certain practicum activities with a score of 1 for complete answers and 0 for an incomplete answer. The students’ questions and answers are presented in Figures 9 and 10 below:
Figure 9. Questions about the Grouping of the Laboratory Materials

Figure 10. Students’ Answer to the Questions about the Grouping of the Laboratory Materials

Based on Figure 10, the majority of students answered incorrect questions for grouping the laboratory materials. The incorrect answer covered laboratory materials for blood type (students only answered blood, while other materials used are serum A and B), the cell structure of plants (students only answered onions, while other materials used are cassava stem cork), diffusion and osmosis (students answered cassava stem cork, while the correct answer was methylene blue for diffusion and potato for osmosis), and respiration of animals (students only answered crickets, while another material is vaseline).

The results of the students' knowledge of the grouping of laboratory materials in the form of percentages reached 83.96% (blood type), 51.88% (cell structure of plants), 6.60% (diffusion and osmosis), 56.60% (food content), and 36.79% (respiration of living things). It can be concluded that the students' knowledge of the grouping of laboratory materials used in practicum materials is poor with an average percentage of 47.16%.

In the experimental process, students were involved in observation, measurement, classification, recording data, forming hypotheses and data generation methods, and changing and controlling variables. Besides, laboratory practice does not only foster academic achievement but also contributes to meaningful learning by supporting knowledge interpretation [28]. Laboratory practicum is expected to provide hands-on experience for students concerning theory and the real world [29], [30] explains the consideration during practicum covering (1) the accuracy of using equipment and materials, (2) the accuracy of following the procedure for implementing practicum, (3) applying K3LH behavior in practicum, (4) use of clothes and practicum equipment, and (5) actions from the understanding of the practicum material. To correlate theory with the real world through practicum activities, students have to be able to understand the materials are used in certain subjects because this can facilitate the process of investigation to achieve the desired goals. The students’ low knowledge of the grouping of materials used in certain practicum can be caused by a lack of understanding of the practicum material.

Based on research conducted by [31], the students' low knowledge of laboratory equipment and materials is due to the limited time allocation for explaining the name, function, procedure to use the laboratory equipment, and the characteristics of laboratory chemicals. The manual used in practicum activities only lists the equipment and materials without explaining the name, function, procedure to use the equipment as well as the characteristics of laboratory chemicals. Further, it is not fitted with pictures so that they do not get new knowledge about the equipment and materials. The practicum manual is designed by the teacher for certain practicum activities and given to students as a guide for the practicum [32].
4. Conclusion
Based on the elaboration above, it can be concluded that students’ level of knowledge of functions, the procedure to use laboratory equipment, and the characteristics of chemicals in the laboratory are good. The level of students’ knowledge of the name of the laboratory equipment is quite good but their level of knowledge of grouping materials is poor. They have not been able to distinguish the names of laboratory equipment in terms of the shape and they have not been able to write the names of the laboratory equipment correctly. The students’ low knowledge of laboratory equipment and materials is due to the limited time allocation for the teacher to explain laboratory equipment and materials in detail. Even, the practicum manual used is not completed with the explanation of laboratory equipment and materials. Therefore, further research is expected to develop a practicum manual that contains pictures of laboratory equipment and materials or even fitted with the video to explain the procedure to use the equipment. Students’ good knowledge of laboratory equipment and materials is important in helping them to succeed in laboratory activities, developing student skills, and reducing accidents in the laboratory.

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