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DESCRIPTION OF OCCUPATIONAL SAFETY UNDERSTANDING AND AWARENESS IN THE LABORATORY OF JUNIOR HIGH SCHOOL STUDENTS IN INDONESIA

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Abstract

Indonesia junior high school students' understanding and awareness of work safety in the laboratory. Laboratory guidelines not only provide practical experience to students but also help students to identify hazardous materials and work safety in the laboratory. This study aims to investigate the scientific understanding and the awareness of Indonesian junior high school students about safety signs in the laboratory. The survey questionnaires were given to 191 third-grade junior high school students who had received work safety material in the laboratory. The findings indicated that the majority of students had misconceptions about the definition of hazardous materials in the laboratory. In addition, they experienced low laboratory work safety awareness. In the interview, the researcher found that students did not pay attention to the safety signs on the packaging label of the material during the experiment. The results of this study fill the gap in laboratory learning studies. The research results also provide information to improve the quality of learning in the laboratory, especially in increasing students' awareness of how to use, store, and properly dispose of materials in the laboratory.

Keywords*: Laboratory safety, lab work, safety awareness, scientific understanding*

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INTRODUCTION

Twenty-first century learning, including science learning, is required to emphasize education that trains students to maximize thinking skills, analyze problems, relate science to events in everyday life, master technology, and develop communication and collaboration skills (Bao & Koenig, 2019). For this reason, science as a subject must be taught contextually by actively involving students in problem-solving so that science learning becomes meaningful for students (Kotkas et al., 2016).

Optimizing laboratory or practicum activities can be a solution to meet the demands of science learning in the 21st century because it allows students to learn through real experiences and improves students' communication and collaboration skills in obtaining new ideas and concepts. Types of experiential learning, such as practicum, can also help students achieve intellectual goals, such as a deeper understanding of the material, improving critical thinking skills and application of knowledge, and encouraging mature abilities to engage in lifelong learning (Eyler, 2009). Practicum is also effective in improving students' cognitive abilities (Mutmainah et al., 2019).

Laboratory or practicum activities are important for science learning. However, the practicum activities carried out must still pay attention to work safety considering the potential hazards that can be caused by chemicals (Alaimo et al., 2010). Materials in the laboratory have many benefits, but they can also pose a danger if you are not careful (ACS Committee on Chemical Safety, 2017). So teachers need to pay attention to the potential hazards that materials can cause in the laboratory. Teachers have a very important role in raising students' awareness of hazardous materials and raise awareness of work safety in the laboratory (Alaimo et al., 2010). In other words, teachers and students must seriously consider the safety factor in school laboratories (Artdej, 2012).

Management of laboratory safety and security is the responsibility of managers and users, so both managers and users must understand knowledge about laboratory safety and security (Sangi & Tanauma, 2018). Unfortunately, previous studies reveal how conditions on the ground differ from expected. Awareness of student work safety is still relatively low, especially regarding material safety, security of work steps, tool management, waste management, and emergency safety procedures (Ali et al., 2018). Students' understanding of safety signs on material labels is even low (Artdej, 2012). But unfortunately, previous studies did not reveal the cause of students' insufficient knowledge and awareness about workplace safety in the laboratory, as will be revealed in this study.

The school where the research is conducted and where the researcher is in charge has an adequate science laboratory. The laboratory has complete equipment and materials. Learning is also often carried out in laboratories according to the curriculum. However, based on observations made during education, students did

not care about safety. Students often joke in the laboratory and are not disciplined in obeying laboratory rules, and it is usually found that some students use tools that are not following their functions. This condition can indicate that the level of knowledge and awareness of students about workplace safety in the laboratory is still lacking. The school does not yet have a workshop manual in the laboratory. The teacher compiles a simple module that contains basic guidelines for working in the laboratory safely to be distributed to students. Facts in the field show that students' responses are not good in accepting the module. Modules are not brought when working in the laboratory for various reasons, so the teacher needs to re-explain each student's practice. Several posters about work safety and the dangers of materials in the laboratory have been hung on the walls. However, posters are less effective in conveying detailed messages because they require image-reading skills to interpret the poster content (Aprilya Winingsih et al., 2020).

This study aims to reveal the level of knowledge and awareness of junior high school students about workplace safety in the laboratory. The results obtained will also be analyzed, as the underlying causes of the effects brought. This research can be important information for the world of education, especially science, where the data can be used as a reference for carrying out learning that emphasizes the importance of knowledge and awareness of work safety in the laboratory. The results of this study also fill the gap in research on practicum-based learning.

RESEARCH METHOD

This research was conducted to investigate the scientific understanding of junior high school students about safety signs in the laboratory and awareness of safe working in the laboratory qualitatively. Data obtained through surveys using questionnaires and interviews were analyzed descriptively. This study uses 2 types of questionnaires adopted from previous studies. The first questionnaire presented in Table 1 was used to measure students' knowledge of safety signs in the laboratory. The second questionnaire, as shown in Table 2, is used to measure the level of safety awareness of students in conducting practicum in the school laboratory.

Before being used, both instruments were tested for validity and reliability. Both instruments were tested on 50 randomly selected samples of class IX students. The validity and reliability of the instrument were calculated statistically using Pearson's Product Moment and Cronbach Alpha techniques with = 0.05. Statistical calculations were carried out with the help of the SPSS application. Based on the calculations, it is known that all the questions in the questionnaire are valid and reliable.

Data collection was carried out from January 4 to February 19, 2021. Participants filled out questionnaires to answer face-to-face interview questions at SMP Negeri 1 Juwangi with a strict schedule and health protocol arrangements. The participants in this study were 191 grade IX students who were taken by purposive sampling from 576 students of the SMP Negeri 1 Juwangi population. Class IX students were taken as participants because they had obtained material on work safety in the laboratory and were considered the most experienced in practicing in the laboratory.

This research begins with planning, where the researcher, a science teacher, identifies the problem and finds the variables and objects to be studied. A literature study was conducted to strengthen the research basis and was used as a reference in preparing plans. The researcher then compiled and validated the instrument with the techniques described earlier. Instruments that have been repaired and are valid are used for data collection.

The first research instrument, as shown in Table 1, was used to measure students' knowledge of safety signs in the laboratory. In this instrument, students are assigned to match 10 materials in the laboratory in column A with 9 types of signs accompanied by a brief description of safety signs in column B. Adding a short description of safety signs aims to reduce incorrect responses because students misunderstood the signs.

Student responses from questionnaire data were analyzed using score analysis. Each correct answer where the student can match the name of the material with the safety mark is given a score of 1, while the wrong and unanswered answers are given a score of 0. The data on the student response scores are then analyzed for frequency, percentage, and average and analyzed descriptively.

The second research instrument shown in Table 2 was used to measure the level of safety awareness of students in conducting practicum in the school laboratory. This questionnaire consists of 10 statements about safety in the laboratory on a Likert scale with a score range of 3 as presented in Table 2.

Table 1. Sample Safety Signs Knowledge Questionnaire in the Laboratory

	Material's Name	Answer		Safety Sign
(A)	Hydrochloric acid	……	(1)	T  Toxic
(B)	Natrium hydroxide	……	(2)	Xn  Hazardous
(C)	Hydrogen peroxide	……	(3)	c  Corrosive
(D)	Ethanol	……	(4)	Xi  Causes irritation
(E)	Methanol	……	(5)	E  Easy to explode
(F)	Natrium chloride	……	(6)	O  Oxidator
(G)	Oil and fat	……	(7)	F  Flammable
(H)	Ammonium hydroxide 20%	……		 No sign
(I)	Reagents	……		N  Damaging the environment
(J)	Acetic acid	……		

Source: Artdej (2012)

Data from the questionnaire responses were analyzed for frequency, percentage, and average and then analyzed descriptively to obtain information related to student safety awareness in laboratory practices. The analysis results are then described based on the guidelines in Table 3 to get conclusions.

Interviews were used to determine students' understanding of safety signs and safety awareness in the laboratory. The interview questions included all security marks and all statement items displayed in the questionnaire. In the interview, the researcher also explored several reasons for the condition of understanding and awareness of work safety in the laboratory. A total of 20 students from the sample were randomly selected for individual interviews. Each student interviewed was asked the same question about the meaning of safety signs and interviewed for approximately 10 minutes. Interview response data were analyzed to strengthen the questionnaire data in reaching conclusions.

Table 2. Example of a Safety Awareness Questionnaire for Working in the Laboratory

Item	Question	Disagree (1)	Neutral (3)	Agree (5)
1.	A laboratory is a place full of safety risks.			
2.	My school laboratory has clear and easy-to-understand safety guidelines			
3.	The teacher explains the rules in the laboratory to maintain the safety			
4.	The teacher or other person in charge always supervises student practicum and always reminds the correct and safe way to do the practicum			
5	I comply with the safety guidelines in my school laboratory			
6.	I always read carefully the procedures for conducting practicums to maintain the safety			
7.	I do practicum seriously and thoroughly to maintain the safety			
8.	I clean and tidy up the tools and materials after doing the practicum			
9.	My school laboratory has adequate safety equipment (fire extinguishers, lab coats, gloves, practical glasses, etc.)			
10.	My school laboratory has safety procedures in case of work accidents.			

Source: Ali et al. (2018)

Table 3. Descriptive Guidelines for Average Questionnaire Score

Average Score	Description
$5.0 \leq y < 4.0$	High
$4.0 \leq y < 2.0$	Average - high
$3.0 \leq y < 2.0$	Average - low
$2.0 \leq y < 1.0$	Low

Source: Ali et al. (2018)

RESEARCH RESULTS AND DISCUSSIONS

Data respon pada kuesioner pertama menunjukkan bahwa sebagian besar siswa memiliki skor rata-rata yang rendah yaitu sebesar 2,72. Data frekuensi dan persentase respon siswa disajikan dalam Tabel 4.

Tabel 4. Data Ferekuensi dan Persentase Respon Siswa

Material's Name	Correct Answer		Wrong Answer		Did Not Answer	
	N	(%)	N	N	(%)	N
Hydrochloric acid	86	45.0	102	53.4	3	1.6
Natrium hydroxide	78	40.8	113	59.2	0	0.0
Hydrogen peroxide	24	12.6	160	83.8	7	3.7
Ethanol	31	16.2	151	79.1	9	4.7
Methanol	27	14.1	164	85.9	0	0.0
Natrium chloride	63	33.0	127	66.5	1	0.5
Oil and fat	39	20.4	148	77.5	4	2.1
Ammonium hydroxide 20%	71	37.2	120	62.8	0	0.0
Reagents	43	22.5	147	77.0	1	0.5
Acetic acid	57	29.8	128	67.0	6	3.1

Table 4 shows that most of the students in the sample could not match the 10 materials in the laboratory with their safety marks correctly. There are only two ingredients, Hydrochloric acid, and Sodium hydroxide, where the number of students who can precisely match the material with its safety mark is close to 50%. The materials used in the instrument have been used in previous practicums. However, the data showed that

students did not understand the meaning of the safety marks on the ingredient labels. Most students misjudge that Sodium hydroxide is not corrosive. Sodium hydroxide in solid or solution can cause serious burns if students make contact without safety equipment such as goggles and gloves. Therefore, it must be labeled as corrosive. Most students can't even match the materials they are close to in their daily life, such as ethanol, sodium chloride, oil, fat, and acetic acid. Most students also mistakenly think Sodium chloride is not harmful to health because students can safely use it in their daily lives. However, sodium chloride is irritant when it comes to skin and eyes.

Table 4 also reveals that Hydrogen peroxide, Ethanol, and Methanol are the three materials with the lowest percentage of correct answers. The three materials include materials that students in practicum have used. These three materials are more often used during the practicum than hydrochloric acid, which has the highest percentage. Ethanol is an ingredient in the material for the fermentation reaction process, while students commonly use methanol as fuel in the laboratory. Researchers have never used hydrogen peroxide in practicum with students in the laboratory, but hydrogen peroxide has been discussed in class IX material for Compiling Objects and Living Creatures. These results indicate that the learning carried out is less than optimal and less meaningful, where students only know without understanding what is being learned if what is learned is not presented in real terms. This result is an interesting finding as well as a note for researchers to present and introduce the name of the material, the form of the material, along with safety signs and how to treat the material in non-practical learning. According to Piaget's theory of cognitive development, junior high school students are already in the formal operational stage. They require concrete operations to form more complex operations (Ibda, 2015).

Interviews were conducted on randomly selected samples. Ten students represented the interview sample with the highest score and 10 with the lowest filling out the first questionnaire. The interview results showed that some students understood the meaning of all the safety signs but did not know what chemicals matched the safety signs. Students do not pay attention to the safety signs on the label during the experiment; the most important thing is that they only complete the practicum correctly. This study's results align with previous research, which found that most students did not read the safety signs on the material labels because they thought that following practical procedure was sufficient (Walters et al., 2017).

Interviews also revealed the causes of students' lack of knowledge. Students stated that they had forgotten the safety material in the laboratory that had been taught. Several other students indicated that they lacked laboratory work safety information. In fact, in the laboratory, some manuals are always available. This shows students' weak scientific literacy level because they are not trained in learning and become a reflection for teachers to carry out more meaningful learning. The low scientific literacy ability of these students can be improved by familiarizing students with an understanding of everyday phenomena in education (Erna Muliastrini et al., 2019), providing opportunities for students to ask questions and express opinions (Juriah & Zulfiani, 2019), communicate and relate the knowledge they have learned. possessed with science topics (Putri et al., 2014), so that students can improve cognitive learning outcomes and skills (Permana et al., 2015). Teachers can also apply innovative learning models that train students to get used to explaining scientific phenomena, evaluating and designing research, interpreting data, and drawing conclusions systematically (Alatas & Fauziah, 2020).

To obtain deeper data and to determine the level of awareness of work safety in the laboratory, students also filled out a questionnaire on the second instrument. The results of the safety awareness instrument analysis in the laboratory are presented in Table 5. The average score obtained by students is 2.71. Based on the criteria guidelines shown in Table 3, students' level of awareness about workplace safety in the laboratory is classified as medium-low. It should be noted in items 2, 4, 9, and 10 that the scores of students who get 5 points are only 14% to 17%. In addition to obtaining the low student safety awareness score results, this questionnaire also described the elements that can be described as the cause of the low score. These elements are safety guidelines in the laboratory, the role of the teacher or person in charge of the laboratory, supporting infrastructure for work safety in the laboratory, and clear safety procedures in the event of an accident.

Interesting results are shown in Table 5, where only 29.8% of students considered the laboratory a risky place. This result has been seen since the observation stage before the study. Students look relaxed, joking, and not serious, even walking around while doing practice. This result follows the questionnaire score, which shows that only 20.9% of students do practicum seriously and thoroughly. This is a note for researchers to insert special material in learning, for example, as an enrichment of the ins and outs of the laboratory. If the misunderstanding among students who consider the laboratory a safe place continues, it is feared that one day it will cause a fatal work accident. Materials in the laboratory have many benefits, but they can also pose a danger if you are not careful (ACS Committee on Chemical Safety, 2017). So teachers need to pay attention to the potential hazards that materials can cause in the laboratory. Teachers have a very important role in

raising students' awareness of hazardous materials and raising awareness of work safety in the laboratory (Alaimo et al., 2010). In other words, teachers and students must seriously consider the safety factor in school laboratories (Artdej, 2012).

Table 5. Results of Analysis of Work Safety Awareness Instruments in the Laboratory

Item	Question	Disagree (1)	Neutral (3)	Agree (5)
1.	A laboratory is a place full of safety risks.	76 (39.8%)	58 (30.4%)	57 (29.8%)
2.	My school laboratory has clear and easy-to-understand safety guidelines	31 (16.2%)	47 (24.6%)	113 (59.2%)
3.	The teacher explains the rules in the laboratory to maintain the safety	67 (35.1%)	46 (24.1%)	78 (40.8%)
4.	The teacher or other person in charge always supervises student practicum and always reminds the correct and safe way to do the practicum	30 (15.7%)	32 (16.8%)	129 (67.5%)
5	I comply with the safety guidelines in my school laboratory	80 (41.9%)	42 (22.0%)	69 (36.1%)
6.	I always read carefully the procedures for conducting practicums to maintain the safety	90 (47.1%)	53 (27.7%)	48 (25.1%)
7.	I do practicum seriously and thoroughly to maintain the safety	122 (63.9%)	29 (15.2%)	40 (20.9%)
8.	I clean and tidy up the tools and materials after doing the practicum	70 (36.6%)	35 (18.3%)	86 (45.0%)
9.	My school laboratory has adequate safety equipment (fire extinguishers, lab coats, gloves, practical glasses, etc.)	27 (14.1%)	21 (11.0%)	143 (74.9%)
10.	My school laboratory has safety procedures in case of work accidents.	28 (14.7%)	31 (16.2%)	132 (69.1%)

There is a contradiction in the seventh question about the seriousness of students in carrying out practicums in Table 5. A total of 122, or 63.9% of students, stated that they had carried out each practicum seriously and thoroughly. At the same time, other results show that only 47.1% of students carefully read safety procedures, and only 36.6% clean tools and materials after the practicum. These results indicate that students consider practicum only to focus on procedural matters such as work steps. Whereas practicum is the entire work process from preparation to delivery of results (ACS Committee on Chemical Safety, 2017).

There is a contradiction in the seventh question about the seriousness of students in carrying out practicums in Table 5. A total of 122, or 63.9% of students, stated that they had carried out each practicum seriously and thoroughly. At the same time, other results show that only 47.1% of students carefully read safety procedures, and only 36.6% clean tools and materials after the practicum. These results indicate that students consider practicum only to focus on procedural matters such as work steps. Whereas practicum is the entire work process from preparation to delivery of results (ACS Committee on Chemical Safety, 2017).

Table 5 shows that 39.8% think the laboratory is full of risk. Even though it is clear that school laboratories store chemicals that can potentially cause danger, the student's assumption can be explained by analyzing the second question about the adequacy of the information. 59.2% of students stated that school laboratories do not have safety guidelines. There need to be warnings about potential hazards in the laboratory in the form of pocketbooks, posters, or other types to increase student awareness of work safety in the laboratory. Students need sufficient information about work safety, not only in the subject matter in class. Sufficient information encourages awareness of student work safety, and one of the sources of information that students consider effective is safety manuals (Fagihi, 2018).

Safety manuals can help teachers to remind the importance of maintaining workplace safety. So far, even though the teacher always reminds them before the practicum to work carefully, students are often indifferent because they are busy preparing for the practicum. Safety manuals can be used as alternative media for learning in the laboratory (Fagihi, 2018). In this digital era, pocketbooks in the form of digital applications are also effective in helping students understand and gain knowledge about laboratory safety procedures (Friska et al., 2017).

A total of 67.5% of students stated that the teacher lacked supervision when students did practicum. Whereas in addition to playing a role in growing student awareness of hazardous materials and raising awareness of work safety in the laboratory, teachers are also responsible for maintaining student safety (Alaimo et al., 2010). The absence of a laboratory assistant makes teachers have to supervise 32 students in practical learning. A laboratory assistant or assistant in a laboratory is very important in determining the success of the practicum (Sunardiyo, 2014). The researcher believes that this limitation can be minimized with the help of manuals and a good explanation of the practicum that will be carried out, along with the potential dangers.

The manual can explain the work steps in detail and convey what students can and cannot do in the laboratory. The manual can contain general rules and safety guidelines to help protect students from injury due to work accidents while preventing tools and materials and the environment from being damaged (Frazier & Sterling, 2005). The manual can be packaged as a module that is reproduced and used continuously.

Modules can make practical activities more focused. The practicum activities in the module allow students to be actively involved in the learning process. Practical activities can accommodate students to develop their thinking skills and abilities (Sari & Sugiyarto, 2015). Student activities can also be increased through practicum modules in learning (Safitri et al., 2018).

This study also revealed that only a small number of students (36.6%) cleaned the tools and materials after the practicum. Based on the results of interviews, students rely on friends for cleaning tools and materials. Others did not clean the tools and materials, leaving the teacher to clean them. Students who clean materials also do not pay attention to safety. The interview results show that students who clean the remaining practicum material often come into direct contact with the leftover material. They argue that the remaining materials of the lab are no longer dangerous because they have reacted. Waste materials that are not managed properly can harm themselves and the environment (Ali et al., 2018). This lack of precise waste management reflects the lack of education for students. Using educational posters on practicum waste management can help students manage the rest of their practicum well and not rely on teacher explanations (Ali et al., 2018).

Table 5 shows that, according to students, schools do not have enough safety equipment for students, such as practicum coats, practical glasses, gloves, and fire extinguishers. This is quite worrying, considering previous research revealed that negligence in using safety equipment could cause work accidents and sometimes even death (Ménard & Trant, 2020). Schools must take this problem seriously by drawing up a budget for procuring safety equipment in the laboratory. However, good school facilities can support optimal learning and help students achieve academic achievement (Koroye, 2016). As practitioners in the field, teachers can help optimize existing laboratory equipment into practicum kits.

The kit is part of a micro-scale, cost-effective, time-friendly, and environmentally friendly lab equipment to carry out certain laboratory work. Kits are usually plastic-based practice kits that are small in size, very simple and easy to use, and easy to clean. Practical tools and materials are arranged on a small scale, so the practicum work budget remains low. Kits combined with innovative learning support students in achieving better process skills (Hanson & Acquah, 2014).

Procedures for handling work accidents in the laboratory are very important to avoid a more serious level of injury due to accidents. Although these procedures are the primary responsibility of schools and teachers, students must also have sufficient knowledge of emergency aid in laboratory accidents. With this knowledge, students cannot panic and respond well if something unwanted happens (Ali et al., 2018). The results showed that 132 students (69.1%) were unfamiliar with security procedures. Even though the school already has the procedure, it is only installed in the front of the laboratory. Teachers must educate about this, considering that work accidents can occur anytime.

The procedure for handling work accidents in the laboratory includes two main elements: infrastructure and systems (Ali et al., 2014). Infrastructure refers to the necessary emergency equipment, such as fire extinguishers, breathing apparatus, first aid kits, eye washers, etc. The system relates to emergency response procedures such as maps and evacuation routes, directions for gathering points, clear directions, and education of emergency handlers (Freeman & Whitehead, 1984).

With good accident-handling procedures, students understand what needs to be done if an incident occurs. Emergency response procedures must be comprehensive, ensuring that all elements in the laboratory understand the application of infrastructure and systems in an emergency. The researcher's opinion is supported by previous research, which showed that 28.4% of students were unsure about the infrastructure in emergency response procedures in school laboratories, while another 41.9% were uncertain of the existence of a disaster emergency system in the laboratory (Ali et al., 2018). In this regard, schools need to program disaster emergency training, including accidents in the laboratory.

The results of this study indicate the low level of understanding and awareness of students as a whole about work safety in the laboratory. The score of student understanding has an average score of 2.71, while

the score of student awareness of work safety is in the medium-low category with an average score of 2.72. The study's results also indicated 4 main reasons for the low score. These four things are the teacher's role in carrying out meaningful learning to grow and improve student understanding, the availability of clear safety guidelines in the laboratory, the availability of supporting infrastructure for work safety in the laboratory, and the availability of clear safety procedures in the event of an accident in the laboratory. However, these results are limited to certain urban and rural schools in a limited sample size. There is room for further improvement in increasing students' understanding and awareness of laboratory work safety in Indonesia.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

The results of this study indicate that most students do not understand the meaning of the safety signs of materials in the laboratory. The results also reveal how low students' level of awareness about workplace safety in the laboratory is. This condition is caused by 4 things: the lack of meaningful learning, the absence of work safety guidelines for students, the lack of supporting facilities, and the lack of supervision from the teacher when students do the practicum.

B. Recommendations

This research becomes information for further research for appropriate teaching techniques to increase students' understanding of safety signs in the laboratory and help students grow awareness of work safety in the laboratory. This research is also a signal for science teachers to adjust learning to emphasize to students the importance of understanding safety signs on materials and awareness of work safety in the laboratory. This research is still limited to a limited sample, thus opening up opportunities for further research to examine a wider sample.

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