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Safety First? Exploring Occupational Health and Safety Knowledge Levels of Chemistry Education Students in Laboratory Settings

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ABSTRACT

Purpose of the study: The main objective of this study is to identify students' knowledge of Occupational Safety and Security.

Methodology: One hundred and eighty three (183) students of the Chemistry Education study program, Faculty of Tarbiyah and Teacher Training, Syarif Hidayatullah State Islamic University, Jakarta, participated in answering the test on Occupational Safety and Security. This test was developed based on three Occupational Safety and Security indicators, namely storing, general work procedures (handling), and disposal of hazardous chemicals.

Main Findings: Based on data analysis, it was found that on average students have insufficient knowledge about the three Occupational Safety and Security indicators (38%). In detail, the indicator for storing is 33%, general work procedures is 34%, and the last is for disposing of hazardous chemicals is 47%. The results obtained have not been able to show students' general knowledge about Occupational Safety and Security, but can be an early warning to realize the importance of Occupational Safety and Security knowledge for students when experimenting in a chemistry laboratory.

Novelty/Originality of this study: This study examines the level of knowledge of Chemistry Education students regarding the principles of (Occupational Safety and Security) in the laboratory, which is an innovative step in increasing awareness and implementation of safety protocols in practical learning.

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1. INTRODUCTION

Chemistry is a branch of natural science that studies the properties, structure, and changes in substances or materials [1]-[3]. Unfortunately, observations show that chemistry is often considered difficult and confusing by students. This is due to the stereotype that chemistry is identical to complicated procedures and the use of hazardous substances in the laboratory [4]. This image creates a negative perception, so that many students feel afraid or are not interested in studying it [5], [6]. This condition affects students' interest in developing chemistry further.

The chemistry learning process is designed to provide students with hands-on experience through experiments [7]-[9]. This hands-on experience helps students understand previously difficult chemical concepts. Experiments are usually conducted in a chemistry laboratory, a place equipped with a safety system to support learning [10]-[12]. However, observations show that chemistry laboratories are often not optimally utilized in the learning process. As a result, students' understanding of chemistry and the application of safety procedures are limited [13].

In addition to being a learning tool, the chemistry laboratory plays an important role in instilling awareness of the importance of Occupational Safety and Security [14]-[16]. Chemistry Education students are required to understand and cultivate Occupational Safety and Security as a provision for their future [17]-[19]. This awareness is needed because graduates of the Chemistry Education study program are expected to become responsible educators, industrial workers, or scientists. By cultivating Occupational Safety and Security, students can carry out experiments safely and according to procedures. This is also important to minimize the risk of accidents during the experimental process.

Experiments in a chemistry laboratory involve chemicals that can provide benefits as well as risks to humans and the environment. Therefore, the implementation of Occupational Safety and Security procedures is a must to maintain safety [20], [21]. Regulations such as Government Regulation of the Republic of Indonesia No. 74 of 2001 and Permendikbud of the Republic of Indonesia No. 49 of 2014 have established the importance of Occupational Safety and Security standards in higher education. In addition, the AUN-QA standards also emphasize the need for universities to ensure safety in research and learning. By complying with these regulations, students are expected to be able to carry out experiments safely and responsibly.

However, there are still many experiments that do not comply with Occupational Safety and Security standards in chemistry laboratories [22], [23]. This causes work accidents that endanger students and damage laboratory facilities. The main causes include the lack of Occupational Safety and Security curriculum, limited laboratory facilities, and minimal supervision during the experiment [24], [25]. In addition, limited time for experiments often makes students ignore safety procedures. Students' understanding of the importance of Occupational Safety and Security is also still low, so a comprehensive solution is needed [26], [27].

Knowledge of Occupational Safety and Security is a basic element that students must have before conducting experiments in a chemistry laboratory [15], [28], [29]. This knowledge includes an understanding of the dangers of chemicals, how to handle them, and risk prevention measures. Measuring the level of knowledge is important to determine the extent of students' understanding of Occupational Safety and Security [30]-[32]. The measurement results can be a reference for improving Occupational Safety and Security learning and implementation. Thus, lecturers and laboratory assistants must play an active role in providing Occupational Safety and Security learning to students [33]-[35].

Explicit gap analysis between the three studies shows that Fatemi et al. [22] focuses more on the implementation of HSE risk assessment in the laboratory through a case study approach, which focuses on technical procedures and risk management in a professional laboratory environment. Meanwhile, Kavouras et al. [25] discusses the importance of occupational safety and health in the context of sustainability in general, but does not specifically examine the implementation or level of individual understanding of occupational health and safety aspects. Both have not touched on the educational aspect, especially in the context of chemistry education. Herein lies the gap: no study has directly evaluated the level of knowledge or awareness of chemistry education students regarding occupational safety and health in the laboratory. The current study fills this gap by exploring how chemistry teacher candidates understand and apply occupational health and safety principles in educational laboratory practices, which is a crucial aspect in building a safety culture since the study period.

This study has significant novelty and urgency in the context of science education. The novelty lies in the focus of an in-depth evaluation of the level of knowledge of occupational health and safety of chemistry education students, which has so far been more focused on the practical aspects or cognitive achievements alone. In fact, chemistry laboratories have high potential risks that require adequate awareness and understanding of occupational health and safety from an early age [36], [37]. The urgency of this study is also getting stronger along with the increasing demands for safety standards in higher education institutions, as well as the increasing number of laboratory incidents caused by negligence or lack of basic knowledge of occupational health and safety. By understanding how prepared students are to face potential hazards in the laboratory, this study makes an important contribution to designing educational interventions that are not only technical in nature, but also shape a culture of safety in chemistry education.

Based on this background, this study aims to examine the level of knowledge of Occupational Safety and Security of Chemistry Education students at Syarif Hidayatullah State Islamic University of Jakarta. This study is expected to provide an overview of students' understanding of the importance of Occupational Safety and Security in experiments. In addition, the results of the study can be the basis for curriculum development and improvement of laboratory facilities that support Occupational Safety and Security. With this approach, it is expected to create a safer, more effective learning environment that supports the development of chemistry.

2. RESEARCH METHOD

2.1. Research Methods and Design

The research that aims to identify and determine the quality of the level of knowledge of Occupational Safety and Security of the research sample uses a descriptive research method. Descriptive research is a research method that shows to describe existing phenomena, which are taking place at present or in the past [38], [39]. With the descriptive method, the knowledge (cognitive) of Occupational Safety and Security owned by chemistry education students will be described based on existing facts and the factors that influence them, and then analyzed and concluded in general regarding the quality of the level of knowledge (cognitive) of Occupational Safety and Security of chemistry education students.

2.2. Population and Sample

The population in the study were all chemistry education students at the Faculty of Islamic Education and Teacher Training, Syarif Hidayatullah State Islamic University, Jakarta. The sample in the study were chemistry education students in grades I, II, and III at the Faculty of Islamic Education and Teacher Training, Syarif Hidayatullah State Islamic University, Jakarta. At grade IV and above were not used as research samples because students in semester 8 (eight) were carrying out Integrated Teaching Professional Practice and at the following levels were students who were not active in carrying out learning in class and the laboratory. Chemistry education students at grades I, II, and III were used as research samples because students at these levels had received Laboratory Engineering courses and Occupational Safety and Security training/workshops (or Chemical Laboratory Safety and Security) and were still active in carrying out learning in class and the laboratory. Chemistry education Level I were students in semester 2 (two), level II were students in semester 4 (four), and level III were students in semester 6 (six). The total number of research samples was 183 students. Details of the number of research samples are in Table 3.2. The details are as follows:

Table 1. Research Sample

No.	Student Level	Amount	
		Class A	Class B
1.	I	30	30
2.	II	28	30
3.	III	32	33
	Total	183 Students	

Therefore, the sampling technique used is purposive sampling because the research sample is determined with certain considerations.

2.3. Data collection technique

Data collection techniques that aim to determine the level of knowledge (cognitive) of research samples are using tests and non-tests [40], [41]. Tests are conducted in writing using objective questions with multiple choices (five choices). Non-tests are conducted by means of structured interviews.

Data collection using written tests is carried out in stages: preparation (such as preparing research instruments, place, time and instructions), implementation of written tests (which are also supervised and provide instructions needed by the research sample), and collecting the results of written tests that have been given to the sample (which are used as research data). Written tests can be carried out in the classroom or in the chemistry laboratory (by adjusting the conditions, funds, time, and energy). The time given to carry out the written test is 1 (one) hour of learning (± 45 minutes). The instructions given are generally to remind and clarify the rules in carrying out written tests. The written test that has been carried out on the research sample (183 chemistry education students) is data in the main research, which will later be analyzed to obtain the main conclusions in the research.

Non-test data collection with structured interviews is carried out in stages: preparation (such as preparing the number of samples, research instruments, place, time and facilities), conducting interviews (submitting questions using a structured interview guide sheet, and a voice recorder), and recording (collecting) the results of interviews that have been given samples (which are used as research data). Interviews were only conducted for 5 samples (chemistry education students) who were suspected of being able to provide additional information (complementing the main data) on the research data, and also to see the emphasis on the results of the quality of the level of Occupational Safety and Security knowledge possessed by the research sample. The questions asked include the sources of Occupational Safety and Security knowledge possessed by the research sample and the understanding of Occupational Safety and Security that has been possessed by the research sample. Interviews can be conducted anywhere (by adjusting conditions, funds, time, and energy). The questions given to the research sample are adjusted to the questions on the structured interview guide sheet. The time given to conduct the interview is ± 15 minutes. The results of the interviews that have been conducted are supporting research data (information) from the main research data, which will later complement the main conclusions of the research results. Data collection techniques are basically in the form of providing research instruments to research samples, and then analyzing and concluding the results of the research that has been carried out..

2.4. Research Instruments

The research instrument used to identify and determine the quality of the level of knowledge of Occupational Safety and Security of the research sample is to use objective questions with multiple choices (five choices) and a structured interview guide sheet. The instrument grid in this study can be seen in the following table:

Table 2. Written Test Instrument Grid

Material	Learning Indicators	Number of question indicators
Storage of hazardous chemicals	Determine storage of hazardous chemicals	16
General working procedures (handling) of hazardous chemicals	Determine general working procedures (handling) of hazardous chemicals	22
Disposal of hazardous chemicals	Determine disposal of hazardous chemicals	12

Table 3. Non-test Instrument Grid

Research Focus	Indicator	Number of question descriptions
Occupational Safety and Security knowledge sources	Mention the sources of Occupational Health and Safety knowledge that he/she has	3
	Mention the Occupational Safety and Security knowledge that has provided the sources of Occupational Safety and Security knowledge (during the practicum in the chemistry laboratory)	2
Occupational Safety and Security understanding	Explain the 6 question items numbered in the 6 discussions (which are in the discussion chapter) of the Occupational Safety and Security standard (competency) question items with the Occupational Safety and Security knowledge and understanding that he/she has	12

2.5. Data Analysis Techniques

Descriptive research that aims to identify and determine the quality of the level of knowledge of Occupational Safety and Security possessed by the research sample using objective questions with multiple choices (five choices) and structured interview guide sheets, then the analysis technique used for the written test question instrument is the quantitative descriptive analysis technique and the analysis technique used for the structured interview guide sheet instrument (non-test) is the qualitative descriptive analysis technique.

The quantitative descriptive analysis technique for the written test question instrument (against learning indicators in the Occupational Safety and Security standard and question items in the Occupational Safety and Security standard) is carried out in 3 (three) steps, namely adding, comparing and percentageing, and concluding the results of the percentage obtained.

The qualitative descriptive analysis technique for the structured interview guide sheet instrument (non-test) is carried out in the following way: words or sentences that emerge from the interview results (using a structured interview guide sheet and a voice recorder) will be additional information that is useful for completing the results of the main research data (quantitative). So that the emphasis on the results of the quality of the level of Occupational Safety and Security knowledge possessed by the research sample will be more visible.

2.6. Research Procedures

This research procedure was carried out through a descriptive approach that aims to describe factually and systematically the level of knowledge of Occupational Safety and Security of chemistry education students in a laboratory environment. The subjects of the study were students in grades I, II, and III in the Chemistry Education Study Program, Faculty of Tarbiyah and Teacher Training, Syarif Hidayatullah State Islamic University of Jakarta, who were selected purposively based on their active involvement in classroom and laboratory learning, and had attended courses and training related to Occupational Safety and Security. Data collection was carried out through two techniques, namely a written test with multiple choice questions and a structured interview. The written test was carried out in one session for ± 45 minutes, with questions covering indicators of knowledge about the storage, handling, and disposal of hazardous chemicals. Meanwhile, interviews were conducted with five selected students to qualitatively explore their in-depth understanding and sources of knowledge related to Occupational Safety and

Security. The research instrument consisted of an objective question grid and a structured interview guide that had been adjusted to the Occupational Safety and Security competency standards. Quantitative data were analyzed using quantitative descriptive analysis techniques in the form of calculating the percentage of achievement, while qualitative data from the interview results were analyzed descriptively to strengthen and complement the main findings of the written test results.

3. RESULTS AND DISCUSSION

The Occupational Safety and Security standard (competency) used (namely determining the management and handling of hazardous chemicals) has 3 indicators, namely 1) determining the storage of hazardous chemicals, 2) determining general work procedures (handling) of hazardous chemicals, 3) determining the disposal of hazardous chemicals. In the indicator determining the storage of hazardous chemicals, there are 6 question indicators with (an average) total percentage of correct answers of 33% (less). The following data regarding the details of the question indicators in the indicator determining the storage of hazardous chemicals (in the Occupational Safety and Security standard) are in the table below:

Table 4. Details of Indicators Determining the Storage of Hazardous Chemicals

Indicator Soal	No. Question	Number of Samples Answering Correctly	%	Quality
Students can mention the characteristics of storing reactive chemicals	3	98	54	Enough
Students can mention the storage of flammable chemicals	6	30	16	Very Less
Given chemicals along with symbols of explosive chemicals, students can estimate the storage of explosive chemicals	7	30	16	Very Less
Given several ways to store chemicals, students can conclude the storage of explosive chemicals	12	76	42	Enough
Given a table of chemical properties and a picture of a chemical storage cabinet, students can conclude the storage of flammable chemicals and oxidizing substances in a chemical storage cabinet	17	68	37	Less
Given a table of chemical properties and a picture of a chemical storage cabinet, students can conclude the storage of oxidizing substances and reducing substances in a chemical storage cabinet	18	56	31	Less
Average			33	Not enough

The question indicator with the highest percentage is in question item number 3, namely students can mention the characteristics of reactive chemical storage, with the percentage of correct answers being 54% (sufficient). The question indicator with the lowest percentage is in question items number 6 and 7, namely students can mention the storage of flammable chemicals, and given chemicals along with symbols of explosive chemicals, students can estimate the storage of explosive chemicals, with the percentage of correct answers being 30% (less).

In the indicator of determining general work procedures (handling) of hazardous chemicals, there are 9 question indicators with (an average) number of correct answer percentages of 34% (less). The following data on the details of question indicators in the indicator of determining general work procedures (handling) of hazardous chemicals (in the Occupational Safety and Security standard) are in the table below:

Table 5. Details of Indicators Determining General Work Procedures (Handling) of Hazardous Chemicals

Question Indicator	No. Question	Number of Samples Answering Correctly	%	Quality
Students can mention general working procedures for reactive chemical analysis instruments (metals)	5	44	24	Less
Students can estimate general working procedures (extinguishers) for flammable chemicals	8	63	34	Less

Given chemicals along with symbols for flammable chemicals, students can conclude general working procedures (heating tools) for flammable chemicals	9	11	55	Enough
Students can conclude general working procedures (types of cutters) for reactive chemicals (metals)	10	51	28	Less
Given several general working procedures for a fume hood, students can conclude general working procedures for toxic chemicals in a fume hood	11	41	22	Less
Given several general working procedures for a freezer, students can conclude general working procedures for reactive chemicals in a laboratory freezer	13	60	33	Less
Given several general working procedures (spills), students can conclude types of toxic chemicals	14	86	47	Enough
Students can give examples of general working procedures that produce flammable chemicals	15	58	32	Less
Given steps for handling explosive chemicals, students can choose the right handling of organic peroxides	16	49	27	Less
Average			34	Not enough

The question indicator with the highest percentage is in question item number 9, namely given a chemical substance along with a symbol for a flammable chemical substance 54, students can conclude the general work procedure (heating tool) for flammable chemicals, with the percentage of correct answers being 55% (sufficient). The question indicator with the lowest percentage is in question item number 11, namely given several general work procedures in a fume hood, students can conclude the general work procedure for toxic chemicals in a fume hood, with the correct answer being 22% (less). In the indicator for determining the disposal of hazardous chemicals, there are 6 question indicators with an (average) percentage of correct answers being 47% (sufficient). The following data regarding the details of the question indicators in the indicator for determining the disposal of hazardous chemicals (in the Occupational Safety and Security standard) are in the table below:

Table 6. Details of Indicators Determining Disposal of Hazardous Chemicals

Indicator Soal	No. Question	Number of Samples Answering Correctly	%	Quality
Given chemical disposal symbols, students can state the meaning of the symbols for explosive chemicals	1	168	92	Very Good
Students can state the main factors that cause explosions in places where explosive chemicals are disposed of	2	115	63	Good
Students can state one of the characteristics of flammable chemicals in disposal sites	4	89	49	Enough
Given data from the MSDS table for chemical disposal, students can conclude that chemicals are flammable, explosive, and reactive	19	38	21	Less
Students can estimate the factors that cause explosive chemicals in disposal sites	20	62	34	Less
Students can estimate the factors that cause reactive chemicals in disposal sites	21	43	23	Less
Average			47	Enough

The question indicator with the highest percentage is in question item number 1, namely given a symbol for chemical disposal, students can state the meaning of the symbol for explosive chemicals, with the percentage of correct answers being 92% (very good). The question indicator with the lowest percentage is in question item number 19, namely given data on the MSDS table for chemical disposal, students can conclude that chemicals are flammable, explosive, and reactive, with the percentage of correct answers being 21% (less).

In the question indicator stating the source of Occupational Safety and Security knowledge that they have, there are 3 question descriptions that are concluded as follows: that the sample has obtained and has Occupational Safety and Security knowledge from lectures with lecturers (in the Laboratory Engineering Course), Occupational Safety and Security training/workshop (Chemical Laboratory Safety and Security), when experimenting in a chemistry education laboratory, and from learning in secondary education (Chemical Analyst Vocational School).

"*... (source of Occupational Safety and Security knowledge, namely) from (training) namely Chemical Laboratory Safety and Security) ... oh yes, during the lab (Laboratory Engineering course) also ... right (during) the practicum (in the chemistry laboratory) ...* " (sample 4).

" *... (source of Occupational Safety and Security knowledge, namely) during high school (Chemical Analyst Vocational High School) I did practical work almost every day, for four years ... participated in (Chemical Laboratory Safety and Security) in the second semester ...* " (sample 1).

From the findings of Occupational Health and Safety knowledge that have been provided by several sources, the sample also concluded that Occupational Health and Safety knowledge is very important for them to be safe and secure when experimenting in a chemical laboratory.

" *... (Occupational Health and Safety is) very important, so that (read: so that) we don't (read: not) get poisoned in the lab (read: laboratory) ...*" (sample 5).

" *... (Occupational Health and Safety is) important, yes for your own safety, so that the practical work runs smoothly ... so that you know that hazardous chemicals are not careless in using them, then if (read: if) they spill or whatever, we can know how to handle them ...* " (sample 3).

In the question indicator mentioning the Occupational Health and Safety knowledge that has been given by the source of Occupational Health and Safety knowledge (during the practicum in the chemistry laboratory), there are 2 descriptions of questions that are concluded as follows: that the research sample has obtained basic knowledge about Occupational Health and Safety which includes knowledge of symbols of hazardous chemical substances, to basic techniques for experimenting with chemistry. However, the sample did not mention all the Occupational Health and Safety knowledge it had due to forgetfulness (lack of ability to memorize).

" *... oh yeah during the lab too ... they taught (Occupational Health and Safety) everything ... just the theory ...* " (sample 4).

" *... MSDS (read: Material Safety Data Sheet) ... if you go to the lab you have to wear a lab coat ... that's what I got during Chemical Laboratory Safety and Security ...* " (sample 5).

" *... just (the task of finding) symbols like that ... (at the beginning of the practicum I got) a lab assignment from Mr. Iwan (a laboratory assistant in chemistry education) ...* " (sample 3).

" *... I'm a chemical analyst graduate ... I already understand how to handle this (spills or chemical accidents) ... " (sample 1). As a result of the forgetting factor (lack of ability to memorize) regarding the Occupational Health and Safety knowledge that had been given by the source, the samples only told about the chronology of when they received Occupational Health and Safety knowledge in the chemistry laboratory…*"

"*... (all) practicums (in the chemistry laboratory) also have (Occupational Health and Safety), we are often reminded (by the laboratory assistant or laboratory assistant) if for example we do a practicum, what is Occupational Health and Safety, we are always reminded ... sometimes (Occupational Health and Safety knowledge) is given (by the laboratory assistant or laboratory assistant) sometimes we find out for ourselves ...* " (sample 2).

"*... (practicums in the chemistry laboratory) all also have (Occupational Health and Safety), yes (practicums in organic chemistry courses usually (apply more Occupational Health and Safety), because all the materials are dangerous ...* " (sample 3).

The findings of the research data aimed to identify and determine the quality of the level of knowledge of Occupational Safety and Security in the chemistry laboratory owned by chemistry education students of Faculty of Tarbiyah and Teacher Training Syarif Hidayatullah State Islamic University of Jakarta (with a sample of 183 students), namely obtained from the findings of data (quantitative) instruments (written tests) objective questions with multiple choices (five choices), and from the findings of data (qualitative) instruments (non-test) structured interview guide sheets. The findings of the data (quantitative) of the research, the level of knowledge of Occupational Health and Safety of the research sample is at a low quality of 38%, and the results of the findings of the data (qualitative) of the research are only as additional information that is useful to complement the findings of the main data (quantitative), so that the emphasis of the results of the findings of the quality of the level of knowledge of Occupational Health and Safety owned by the research sample will be more visible.

From the findings of quantitative research data on the level of Occupational Safety and Security knowledge of samples that produced 38% (of poor quality) is also in line with the findings of qualitative research data. From the findings of qualitative research data conducted with structured interviews showed that not all samples have the same Occupational Safety and Security knowledge due to differences in the types of Occupational Safety and Security knowledge sources obtained by the samples, almost all samples that slightly re-expressed the Occupational Safety and Security knowledge they had due to forgetfulness factors, and the little knowledge to understanding of Occupational Safety and Security owned by the samples because the knowledge obtained from the source was only a little and not all of it was applied when carrying out practical activities in the laboratory. The findings of this study are in line with Lorin's opinion which states that in general there are 3 (three) possible outcomes of learning Occupational Safety and Security that have been given.1 The 3 (three) possibilities are: students do not (lack) knowledge Occupational Safety and Security, students are only (lack) able to memorize/remember knowledge Occupational Safety and Security, and students are (lack) able to memorize/remember and understand knowledge Occupational Safety and Security from the learning outcomes that have been given by educators (lecturers or laboratory assistants and their assistants).

> " *... there are many (practical activities that use tools and chemicals) that are (in the laboratory) ... forgot (about Occupational Health and Safety) ... but I really (read: did not) follow what Chemical Laboratory Safety and Security is ...* "

> " *... yeah, at most, (Occupational Health and Safety knowledge in practical activities) what, yesterday, what was that really concentrated thing, I forgot sis (read: older sister) ... yes, I understand or not (about Occupational Health and Safety) how is it ...* "

In addition to the 3 (three) factors mentioned, it turns out that the qualitative data findings of the study also found several other factors that can influence the level of knowledge and understanding of Occupational Health and Safety of the sample, including readiness, motivation, place and learning media, and learning strategies regarding Occupational Health and Safety. The findings of this study are in line with Muhibbin's opinion that in general there are also several factors that can influence learning outcomes, namely factors from within students, factors from outside students, and learning curriculum factors. 2 Factors from within students include nutrition and illnesses in students, the condition of the five senses possessed by students, the level of innate intelligence of students, interests, talents, motivation, readiness, and fatigue. 3 Factors from outside students include weather conditions, study time, place of study, stationery, learning media, social environment in the community, school, and family. 4 Learning curriculum factors include indicators (learning objectives) that are determined, learning strategies (learning methods and approaches) used, assessment techniques and instruments used to assess learning outcomes. 5 So in general, it was found that the learning curriculum factor was the dominant factor influencing the research findings, although the curriculum factor was also tied to the other two factors because they could not be separated from one another, but the learning curriculum factor was the one that could be controlled (by educators) so that it could appear entirely and could be measured.

> " *... (to maximize understanding of Occupational Health and Safety) yes, every practicum must be practiced (Occupational Health and Safety) so don't just do practicums ... there must be self-awareness ... complete the Occupational Health and Safety facilities ... the room is also enlarged (read: enlarged) ... more introduction (Occupational Health and Safety) again ... students are also given motivation to be aware of the importance of Occupational Health and Safety ...* "

> " *... if we often (practice) we will definitely be able to (spontaneously apply Occupational Health and Safety during practicum) ... only a few what are they called, subjects whose work (practicum) is in groups, ... so there they handle everything themselves ....* "

The learning curriculum factor starts from the determined indicators (learning objectives). Without the presence of Occupational Health and Safety indicators, there will be no implementation of learning (learning methods and approaches) and assessment of learning outcomes. 6 The absence of Occupational Health and Safety indicators that are clearly written in the curriculum of the chemistry education study program results in the unpreparedness of educators in implementing learning and assessing learning outcomes from Occupational Health and Safety optimally because there is no curriculum regarding the learning. 7 Likewise for students, students will not be motivated to study Occupational Health and Safety because there are no demands in the curriculum in the chemistry education study program. The absence of Occupational Health and Safety indicators in practicums in chemistry laboratories can also result in students only focusing on completing a lecture assignment when experimenting and not accompanied by an understanding of the relationship (chemistry) related to the process of experimenting in the laboratory (including the properties of chemicals, how they react, and Occupational Health and Safety). The absence of an assessment of Occupational Health and Safety knowledge indicators and their application of Occupational Health and Safety discipline makes students have no interest (motivation) to know and apply Occupational Health and Safety during practicums in the Occupational Health and Safety laboratory. Students are more motivated by academic assessment (with classroom learning) which has a big impact (30–40%) on their GPA, while the assessment of experiments carried out in the laboratory only accounts for ± 10% of the total assessment of each learning regarding chemistry, so Occupational Health and Safety will not be their main knowledge priority.

> " *... up until now, most of the practicums have been done carelessly and have not implemented Occupational Health and Safety ...* " (sample 4).

> " *... if the practicum grades do not have much influence on AIS (Academic Information System), what does have an influence is the theory (given by the lecturer) in class ... like (read: like) the Mid Semester Exam grades, (also) the Final Semester Exam from the exams in class ...* "

The next learning curriculum factor is the learning strategy (method and learning approach) used. Although it is not written in the chemistry education study program curriculum, (in qualitative data findings) Occupational Health and Safety learning is still given to students by educators in the chemistry learning process with classroom learning (in the Laboratory Engineering Course) or using experimental methods in the chemistry education laboratory. When learning Occupational Health and Safety in the chemistry laboratory, educators only insert Occupational Health and Safety learning before and when students experiment in the laboratory with time, place, tools, and substances that are not optimal. Likewise for students, students will not receive optimal Occupational Health and Safety learning.

The last learning curriculum factor is the assessment techniques and instruments used to assess learning outcomes. Without Occupational Health and Safety indicators, there will be no assessment of learning outcomes regarding Occupational Health and Safety. Differences in techniques and instruments used to assess the results of Occupational Health and Safety learning will also affect the quality of the results to be obtained. The assessment of Occupational Health and Safety learning uses a (written) test with objective questions with multiple choices (five choices) of 21 questions, with the percentage obtained from the average number of samples that answered correctly, namely 38% of which are of poor quality, which can indicate poor quality techniques and assessment instruments or poor quality of students who are able to master Occupational Health and Safety. Factors of techniques and assessment instruments have gone through a trial (standardization) stage aimed at obtaining good learning outcome (written) test instruments. Testing of question items according to Nana Sudjana is in the form of difficulty level, distinguishing power, validity (content, construct, and empirical), and reliability. 8 Although trying to eliminate (reduce) the technical factors and assessment instruments for research results, it cannot be denied that these factors are part of the curriculum factor and it is also possible that the results of the (written) test are also influenced by other factors that have been mentioned.

This study has a positive impact in providing a real picture of the level of knowledge of chemistry education students regarding occupational health and safety in the laboratory. These findings can be a basis for educational institutions, especially chemistry education study programs, to evaluate the effectiveness of occupational health and safety learning and design strategies to improve student understanding through practical and contextual approaches. In addition, the results of this study also contribute to building a safety culture in the academic environment from the early stages of education, which is very important to minimize the risk of laboratory accidents in the future. However, this study has several limitations, including the use of a descriptive approach that only describes conditions without testing the causal relationship between variables, and the limited sample coverage at one institution so that the generalization of the research results is limited. In addition, interviews were only conducted on a small number of respondents, so that the qualitative information obtained does not fully represent the entire student population. Further research is recommended to use mixed methods with a wider scope in order to provide a more in-depth and generalizable picture.

4. CONCLUSION

Based on the findings and discussion of the study, several important conclusions were obtained regarding the level of Occupational Health and Safety knowledge of Chemistry Education students in the chemistry laboratory of the Faculty of Tarbiyah and Teacher Training, Syarif Hidayatullah State Islamic University, Jakarta in 2018. In general, the level of Occupational Health and Safety knowledge of students is in the category of "less" quality, with a percentage of 38%. When viewed from each indicator, the quality of student knowledge shows varying results. In the indicator of knowledge of determining the storage of hazardous chemicals, the level of student knowledge is in the category of "less" with a percentage of 33%. In the indicator of knowledge of determining general working procedures for hazardous chemicals, the results are also in the category of "less" with a percentage of 34%. However, in the indicator of knowledge of determining the disposal of hazardous chemicals, the level of student knowledge shows the category of "sufficient" with a percentage of 47%.

These findings indicate several factors causing the low level of students' knowledge of Occupational Health and Safety. The first factor comes from within the students, namely the lack of motivation to study and apply Occupational Health and Safety comprehensively. The second factor comes from outside the students, namely the limited facilities and infrastructure in the chemistry laboratory that are inadequate to support Occupational Health and Safety learning. The last factor is the absence of a learning curriculum that explicitly contains material on Occupational Health and Safety, so that students do not receive formal, structured learning on this matter. Therefore, efforts are needed to improve students' understanding of Occupational Health and Safety through curriculum development, provision of adequate laboratory facilities, and approaches that can improve students' learning motivation. Further research is suggested to involve more educational institutions so that the results obtained are more representative and can be generalized nationally. In addition, the use of a mixed-method approach can provide a more comprehensive understanding of the factors that influence students' knowledge and awareness of work safety and security in the laboratory.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies

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