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Handbook of Occupational Safety and Health as a Guiding Supplement for Occupational Safety and Health in Chemical Laboratory

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Abstrak

Laboratorium pendidikan kimia memiliki risiko kecelakaan kerja yang lebih tinggi dibandingkan laboratorium untuk kegiatan industri. Banyak kecelakaan kerja terjadi di laboratorium kimia. Dua faktor penyebab kecelakaan kerja adalah perilaku tidak aman dan kondisi tidak aman. Keselamatan dan kesehatan kerja di laboratorium sangat penting untuk menciptakan lingkungan kerja yang nyaman dan aman untuk mencegah atau meminimalkan kecelakaan kerja. Penelitian ini bertujuan untuk menghasilkan buku pedoman keselamatan dan kesehatan kerja di laboratorium kimia sebagai pelengkap panduan praktikum kimia untuk mewujudkan keselamatan dan kesehatan kerja di laboratorium kimia. Penelitian ini merupakan penelitian dan pengembangan (r&d) dengan model pengembangan 4-D yang terdiri dari 4 tahapan utama yaitu: define, design, develop, dan distribute. Penelitian dibatasi pada tahap pengembangan, yang diakhiri dengan uji kepraktisan. Berdasarkan penilaian ahli, ditemukan bahwa buku pedoman keselamatan dan kesehatan kerja di laboratorium kimia sangat valid dari segi isi (3.9), bahasa (4.0), dan media (4.0), dari skor maksimal 4. Dari uji keterbacaan, semua responden diperoleh siswa memahami isi atau informasi yang disajikan dalam buku pedoman kesehatan dan keselamatan kerja laboratorium kimia. Selanjutnya melalui uji kepraktisan diperoleh bahwa dosen, asisten laboratorium, dan mahasiswa memberikan penilaian bahwa buku pedoman keselamatan dan kesehatan kerja di laboratorium kimia masing-masing mendapat nilai 4,0 dan 3,9 yang artinya sangat praktis. Penelitian ini menyimpulkan bahwa buku pedoman keselamatan dan kesehatan kerja laboratorium kimia sebagai pelengkap panduan praktikum kimia ini valid untuk dilaksanakan dari aspek isi, bahasa, media, dan keterbacaan serta sangat praktis dalam penggunaannya

***Kata kunci**: Handbook, Keselamatan, Kesehatan Kerja, Laboratorium Kimia*

Abstract

Chemical education laboratories have a higher risk of work accidents than laboratories for industrial activities. Many work accidents occur in chemical laboratories. Two factors that cause work accidents are unsafe behavior and unsafe conditions. Occupational safety and health in the laboratory are crucial to creating a comfortable, safe work environment to prevent or minimize workplace accidents. This study aims to produce a handbook of occupational safety and health in chemical laboratories as a guiding supplement for chemistry practicum to create occupational safety and health in chemical laboratories. This research is a research and development (r&d) with a 4-d development model consisting of 4 main stages: define, design, develop and disseminate. Research is limited to the development stage, which ends with a practicality test. Based on expert judgment, it was found that the occupational safety and health handbook in the chemical laboratory are very valid in terms of content (3.9), language (4.0), and media (4.0), from a maximum score of 4. From the readability test, all respondents obtained students understand the content or information presented in the chemical laboratory's occupational health and safety handbook. Furthermore, through the practicality test, it was obtained that lecturers, laboratory assistants, and students gave an assessment that the occupational safety and health handbook in the chemical laboratory each scored 4.0 and 3.9, which means it is very practical. This research concludes that the chemical laboratory's occupational safety and health guidebook as a guiding supplement for chemistry practicum is valid to be implemented from the aspect of content, language, media, and readability and is very practical in its use.

Keywords: Handbook, Safety, Occupational Health, Chemical Laboratory

1. INTRODUCTION

A laboratory supports educational institutions in a closed or open space, where this laboratory can be permanent or mobile with systematic management (Loekito et al., 2017; Mauliza & Nurhafidhah, 2018). The laboratory is used to prove science using certain scientific methods in helping the implementation of the continuity of education in Indonesia

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(Abdjul et al., 2019; Dwiningsih et al., 2018a; Yusuf et al., 2018). One of the laboratories in educational institutions is a chemistry laboratory. Chemistry laboratories have a very important role in learning chemistry, namely in testing a science through experiments or practicum (Dwiningsih et al., 2018a; Mauliza & Nurhafidhah, 2018). A chemical laboratory with all the equipment and chemicals is a place that has the potential to pose a very high risk of danger or accident risk for humans and the environment (Hadipranoto et al., 2022; Raharjo, 2020)**.** Educational laboratories often do not have a maximum safety program, so safety is not as much consideration as it should be in educational research institutions. There is a misunderstanding that the potential for harm in educational laboratories is relatively small because they tend to use relatively few chemicals compared to industry, leading to a lack of understanding of potential hazards which ultimately lead to financial losses, equipment damage, occupational diseases, and even worse, death (Olewski & Snakard, 2017; Staseva et al., 2022)**.**

Practicums carried out in chemical laboratories can pose a risk of work accidents from the hazards that can arise when carrying out practicum activities (Leggett, 2012b, 2012a). The risks of work accidents in the laboratory come from several factors, including laboratory user activities, errors in storing laboratory equipment and materials, and errors in laboratory layout. (Alépée, Grandidier, Teluob, & Amaral, 2022; Bourrée et al., 2014). The emergence of risks is not only seen from the incidence of work accidents to humans but also from the damage to tools and practicum materials caused by errors in storage which can also cause these risks. Storage of tools and practicum materials must be by the characteristics of practicum tools and materials, so it is necessary for laboratory managers and users who understand the characteristics of practicum tools and materials to minimize the risk of damage to practicum tools and materials (Alépée, et al., 2022; Bejarano et al., 2022). Errors in laboratory layout also contribute to the emergence of risks in chemical laboratories. The risk of accidents can also be seen from the aspect of environmental pollution caused by the disposal of laboratory waste that is not managed properly.

Previous research findings also revealed that accidents in the laboratory using chemicals resulted from a lack of understanding when managing practicum materials (Alépée et al., 2022; Lasia, 2020). Other studies also state that laboratory facilities and infrastructure are still inadequate, and they still lack an understanding of applying occupational safety and health in practical learning activities (Pangemanan & Rangkang, 2019; Sulistiyowati et al., 2019). Causes of work accidents due to unsafe behavior (88%), unsafe conditions (10%), and unknown reasons (2%) (Council, 2011). Other studies also show that work accidents are caused by unsafe behavior (96%) and unsafe conditions (4%) (Dupont, 2005). Based on these data, it can be concluded that work accidents generally are the main cause of negligence or carelessness. Research findings reinforce this, and the human factor occupies a very important position in work accidents, between 80-85% (Maurits & Widodo, 2008). Therefore, it is necessary to prevent accidents by fostering and developing awareness (attitudes) of the importance of Occupational Safety and Health in the laboratory for those who work in the laboratory.

Work accidents in the laboratory should be prevented or minimized to ensure that laboratory workers are comfortable and safe (Khairudin et al., 2019; Matsun et al., 2016). The risk of work accidents can be minimized through good laboratory management, especially in the aspects of Occupational Health and Safety culture. Work accidents and damage to practicum tools and materials can be prevented or minimized if people who work in laboratories (students/lecturers, laboratory assistants) have a culture of occupational safety and health in the laboratory (Mauliza & Nurhafidhah, 2018; Sulistiyowati et al., 2019). This can be realized by providing Occupational Safety and Health materials in the chemical laboratory. Occupational Safety and Health are important to be implemented in the

laboratory to prevent and reduce the risk of work accidents due to the lack of awareness of laboratory managers on the implementation of Occupational Safety and Health and laboratory infrastructure that is not following Occupational Health and Safety requirements, resulting in work accidents (Cahyaningrum, 2020; Rikhotso et al., 2022). Occupational Health and Safety requires special attention because Occupational Health and Safety is one form of effort to create a workplace that is safe, healthy, and free from environmental pollution to reduce and or be free from work accidents and occupational diseases, which in turn can improve work efficiency and productivity.

The solution offered to cultivate occupational safety and health is by developing the Occupational Safety and Health Handbook in Chemical Laboratories. A handbook contains information regarding certain user handbooks or working procedures that are systematically arranged (Cholimah et al., 2020; Reza & Fauziah, 2019). The elements presented in the guidebook are instructions, instructions, references, prosips, descriptions of the subject matter, materials or ways of working, and answers to questions in related fields (Afiyah & Purnama, 2019; Hidayah & Maharani, 2018). This research is focused on developing an occupational safety and health handbook intended to be used as a supplement to guide chemistry practicums in first and second-type laboratories. The first type of laboratory is a basic science laboratory located in schools at the secondary education level, which provides education and training with supporting facilities for the first and second categories of equipment, and the materials managed are general category materials to serve student educational activities (Burhanuddin et al., 2022; Wiratma, 2014). The second type of laboratory is a science laboratory located in preparatory level universities (first and second semesters) which provides education with supporting facilities for the first and second categories of equipment, and the materials managed are general category materials to serve student educational activities (Gusnani et al., 2018; Raharjo, 2017).

The findings of previous research also stated that in the implementation of practicum activities in the laboratory, a practicum guide was needed so that the practicum carried out went well or followed the objectives to be achieved (Manikowati & Iskandar, 2018; Wahyuni, 2013). Other findings also reveal that handbooks are needed to provide facilities to learn and work smoothly and purposefully (Auliya et al., 2021; Sardi, 2018; Wiratma, 2014). There is no study on chemical laboratory occupational safety and health handbooks as a supplement for practicum guides. The developed practicum guide contains objectives, brief material related to the title to be practiced, tools and materials used, and work procedures. Chemical Practicum Guide serves to prevent work accidents in the laboratory. This research aims to develop a handbook for occupational safety and health in the chemical laboratory as a supplementary practical guide for creating occupational safety and health in the chemical laboratory.

2. METHODS

This research is Research and Development (R&D). Research and development is a method for producing certain products or improving existing products and testing the effectiveness of these products (Dwi Lestari & Putu Parmiti, 2020; Wulandari et al., 2020). In this research, the development aims to produce a new product, the Occupational Safety and Health Handbook in the Chemical Laboratory, as a Supplement to Guiding Chemistry Practicum to Create Occupational Safety and Health in the Chemical Laboratory. The research model used in this study refers to the 4-D model. The 4D development model consists of 4 main stages: Define, Design, Develop and Disseminate (Dwianto et al., 2017).

This research is limited to three development steps: Define, Design, and Develop. The development stage ends with the practicality test. The effectiveness test has not been carried

out due to time constraints. The Disseminate stage is planned to be carried out on the next research opportunity. Product assessment is assessed by subject matter experts, linguists, and learning media experts. The subject of the trial involved nine students. The practicality test involved two lecturers and 20 students. The methods used in collecting data are interviews and questionnaires. The instrument used to collect data is a questionnaire. The instrument grid is presented in Table 1. The technique used to analyze the data is descriptive qualitative and quantitative analysis. Qualitative descriptive analysis was used to analyze the input provided by the expert. Quantitative descriptive analysis was used to analyze data in the form of expert scores.

Table 1. Grid of Readability Test instruments

No.	Rated aspect
1	The sentences are used to represent the information to be conveyed.
2	The use of language does not cause double meaning.
3	The words used are understood (already known)
4	The images presented are informative and make it easier to understand
5	The description of Occupational Safety and Health in the chemical laboratory is easy to understand
6	Systematic clarity of the contents/materials of the Occupational Safety and Health handbook in the Chemistry laboratory
7	The Occupational Safety and Health handbook in the chemical laboratory will help facilitate the implementation of the practicum.

3. RESULTS AND DISCUSSION

Result

This study develops a handbook for occupational safety and health in the chemical laboratory as a supplementary practical guide for creating occupational safety and health in the chemical laboratory. The model used in developing the product is 4D but is limited to the Define, Design, and Develop stages. First, define. A needs analysis is carried out at the define stage through a preliminary study. The analysis results show that writing the Occupational Safety and Health Handbook in the Chemical Laboratory must meet a standard writing rule because students will use the book to conduct laboratory practicals. In addition, because the characteristics of the Occupational Safety and Health Handbook in Chemical Laboratories are enrichment (enrichment books), meaning that they are not tied to certain learning competencies, the Occupational Safety and Health Handbook in Chemical Laboratories can also be used by anyone who needs it.

Second is the design stage. At this stage, the design of the chemical laboratory's occupational safety and health handbook is a supplementary practical guide for creating occupational safety and health in the chemical laboratory. The occupational safety and health handbook developed is enriching so that the presentation of the occupational safety and health handbook in the chemical laboratory is designed with A4 paper size. The font used is Times New Roman 12 and Agency FB. The use of font in the textbook uses the Times New Roman typeface in the description of the material. In contrast, the Agency FB font is used in the chapter and sub-chapter titles so that the title looks contrasting compared to the material description. The material description is presented with 1.5 spaces. Systematics of the Occupational Safety and Health Handbook in the Chemical Laboratory: the title page, foreword, instructions for use, table of contents, CHAPTER I-X, and bibliography.

The third is the development stage. At this stage, it is developing a handbook for occupational safety and health in the chemical laboratory as a practical guide supplement to create occupational safety and health in the chemical laboratory following the previously developed designs. The handbook for occupational safety and health in chemical laboratories that has been developed is then tested for validity and practicality. At the Develop stage, it is divided into two activities, namely: expert appraisal and developmental testing. The expert appraisal is a technique for validating or assessing the feasibility of a product design. In this study, two educational laboratory personnel carried out the expert assessment. The assessment covers aspects of content, language, and media. A summary of the validation results by experts is presented in Table 2.

Table 2. Summary of Content, Language, and Media Expert Validation Results

No	Rated aspect	Average	Category
1	Content Validity	3.9	Valid
2	Language Validity	3.9	Valid
3	Media Validity	3.8	Valid

Table 2 shows that the experts rated it very feasible/ valid on all aspects of product development, namely content aspects 3.9, language aspects 4.0, and media aspects 3.6 (from a maximum score of 4). Some suggestions for improvement from the experts include correcting typing errors (typos), improving the consistency of format and layout of presentation and image layout, and improving image quality. After making improvements according to the advice of experts, the Occupational Safety and Health handbook in the chemical laboratory product development is declared feasible. Then a development test is carried out as a readability test. The readability test involved nine students. The results of the readability test are presented in Table 3.

Table 3. Summary of Readability Test Results

No.	Rated aspect	Not Clear		Less Clear		Clear		Very Clear	
		n	%	n	%	n	%	n	%
1	The sentences used to represent the information to be conveyed	0	0	0	0	2	22,2	7	77,78
2	The use of language does not cause double meaning	0	0	0	0	2	22,2	7	77,78
3	The words used are understandable (already familiar or familiar)	0	0	0	0	5	55,6	4	44,4
4	The images presented are informative and make it easier to understand	0	0	0	0	1	11,1	8	88,9
5	The description of Occupational Safety and Health in the chemical laboratory is easy to understand	0	0	0	0	1	11,1	8	88,9
6	Systematic clarity of the contents/materials of the Occupational Safety and Health handbook in the Chemistry laboratory	0	0	0	0	3	33,3	6	66,7
7	The Occupational Safety and Health handbook in the chemical laboratory will help facilitate the implementation of the practicum	0	0	0	0	1	11,1	8	88,9

The results of the readability test presented in Table 3 show that all students gave a clear assessment or understood until they were very clear or understood very well about the Occupational Safety and Health Handbook in the Chemical Laboratory. After the Occupational Safety and Health Handbook in the Chemical Laboratory is declared valid and can be understood by students, it is followed by a practical test. The practicality test involved two chemistry lecturers and 20 students who had already taken Basic Chemistry Practicum courses. A summary of the practicality test results is presented in Table 4.

Table 4. Summary of Practical Results

No	Rating Indicator	Evaluation			
		Lecturer		Students	
		score	category	Score	category
1	Display Aspect 3.9	3,9	practical	3,9	practical
2	Material Aspect	4,0	practical	3,8	practical
3	Benefit Aspect	4,0	practical	4	practical
	Average	**4,0**	**practical**	**3,9**	**practical**

The results of the practicality test, which are presented in Table 3, show that the product development of the Occupational Safety and Health Handbook in the Chemistry Laboratory is considered practical to be used as a supplement to support the implementation of chemistry practicum by both lecturers and students.

Discussion

Based on the results of data analysis, it was found that the Occupational Safety and Health Handbook in the Chemical Laboratory was considered valid and practical. It is because, first, the book developed can be a guide to make it easier for users. The ease of use of books will make it easier to carry out learning (Asmi et al., 2018; Mauliana et al., 2022; Serevina et al., 2018). The presence of the Occupational Safety and Health Guidebook in the Chemistry Laboratory as a practical guide supplement will assist students in working in the laboratory and conducting practicums comfortably, safely, and free from fear of accidents. The comfort students feel in learning impacts increasing student learning motivation (Asrial et al., 2020, 2021; Komikesari et al., 2020). It can happen because the Occupational Health and Safety handbook as a supplement provides guidance (instructions) on how to work in the laboratory properly and provides information on sources of danger, both from the use of chemicals, safe chemical storage, and disposal of chemicals. Reagent waste follows procedures and uses laboratory equipment based on Occupational Health and Safety procedures (Nurkhomah & Poerwanto, 2022).

Second, handbooks can reduce the risk of work accidents. Working in the laboratory is at risk of work accidents. The risk of work accidents comes from three indicators: user behavior or activities, storage of tools and materials, and layout (Matsun et al., 2016; Mauliza & Nurhafidhah, 2018). The greatest risk of work accidents comes from the activity factor of laboratory users. The results of research support that the biggest source of accidents when doing activities in a chemical laboratory comes from factors of human activity or users and chemicals (Hadipranoto et al., 2022; Muhtaridi, 2011). The risk of work accidents can be minimized through good laboratory management, especially in the aspects of Occupational Health and Safety culture. Work accidents and damage to practicum tools and materials can be prevented or minimized if the people working in the laboratory (students/lecturers, laboratory assistants) have a culture of occupational safety and health. This can be realized by providing Occupational Safety and Health materials in the chemical laboratory.

Third, the handbook also provides personal protective equipment. The Occupational Safety and Health handbook in a chemical laboratories also contains Personal Protective Equipment (PPE), which is recommended when working in a laboratory. One of the important things included in the work procedure is using personal protective equipment, commonly called PPE (Nurkhomah, & Poerwanto, 2022; Rina Mirdayanti & Murni, 2017). If a work accident occurs while working in the laboratory, this handbook has also provided clear instructions regarding the accident prevention actions that must be taken. In addition, this handbook contains laboratory rules and regulations and rules for working in the laboratory. This order is followed like recommendations/orders and not to do prohibited things. Chemical laboratories are workplaces that have many potential hazards (Dwiningsih et al., 2018b; Rahmantiyoko, A., Sunarmi, S., Rahmah, 2019). The findings of previous research also stated that in the implementation of practicum activities in the laboratory, a practicum guide was needed so that the practicum carried out went well or followed the objectives to be achieved (Manikowati & Iskandar, 2018; Wahyuni, 2013). The existence of the Occupational Safety and Health handbook in the laboratory can increase students' awareness, sensitivity, participation, and understanding to comply with the aspects of the order, safety, and health working in the laboratory (Darmawi et al., 2019). This handbook is expected to meet the learning needs of students so that practical activities in the chemistry laboratory become more effective.

4. CONCLUSION

Based on the results of this development research, it can be concluded that product development in the form of a workplace safety and health handbook in the laboratory is considered valid, easy to understand, and practical. Valid means that the Occupational Safety and Health handbook in this laboratory is viewed from the aspect of content, language, and media suitable to be used as a chemical practicum guide supplement, while practical means that from the practical appearance aspect, it is used and provides benefits as a chemical practicum guide supplement.

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