Assessing the feasibility of chemical laboratory safety videos

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Abstract. Laboratory activities are inseparable from learning chemistry. Consequently, chemistry students should master several skills in the laboratory, which they might not have it in secondary school. However, there are many potential hazards to be considered in activities in chemical laboratories. The lack of knowledge and experience of first-year chemistry students causes the possibility of accidents in the chemical laboratory higher. Therefore, in this study, chemistry laboratory safety videos were developed and assessed by experts, while questioners and interviews were used to collect the data. The assessment result is that the videos are feasible and ready to use after the input from experts and users are implemented in the developed videos.

1. Introduction
Learning chemistry in the laboratory has been believed to be able to provide students with more understanding than learning only through textbooks [1]. Nonetheless, experimental activities in chemical laboratories are closely related to the use of tools and chemicals that can cause harm. The chemical substances can behave as corrosive, carcinogenic flammable, irritant, and toxin that associate with the lab equipment usages, which possibly lead them to explosion and implosion due to high pressure or temperature [2]. The possible danger of using tools and chemicals can be caused by small and modest events, but still has a significant impact if exposed to the hazards caused [3]. Therefore, safety is crucial for activities in the chemical laboratory [4]. The likelihood of this danger is heightened by the lack of knowledge and experience in the laboratory. At times, students understand that personal protective equipment is compulsory during a laboratory experiment. However, they do not comprehend the purpose because they cannot relate to how particular hazards require the donning of protective equipment [5]. One alternative that can be done to avoid this risk is to conduct directives in advance related to regulations and aspects of work safety in chemical laboratories [6]. The 2015 ACS Guidelines and Evaluation Procedures for bachelor’s degree Programs clearly state laboratory safety as one of the six proficiencies that should be mastered by chemistry bachelors [7]. To prevent the accident, in 2013, Dow launched a laboratory safety website that contains a comprehensive set of training videos [8]. Students perform self-confidence [9] and display better understanding concepts at carrying out the laboratory procedures when they had learned it from pre-laboratory videos [10]. Moreover, the use of videos has also been proven to improve readiness [11–14] as well as the ability in terms of cognitive, affective, and psychomotor students in laboratory activities [15].

This research is one of a series of studies on students’ readiness to work in a chemical laboratory. Previously, basic skills in the chemistry laboratory and titration videos were developed, which have been validated by experts and users [16,17]. This current research focuses on occupational safety in chemical laboratories. Therefore, the research questions that will be addressed in this study are: (1) What
are the problems of learning in chemical laboratories related to the safety lab? (2) How is the feasibility of chemical laboratory safety videos that have been developed?

2. Methodology

2.1. Participant
This research involved three laboratory assistants and 90 first-year students who took basic chemistry practicum at Universitas Negeri Jakarta, Indonesia, and users of the chemical laboratory safety videos in preparation for basic chemistry practicum. Also, to assess the quality of the videos, three experts in the field of chemistry and technology in education were involved.

2.2. Instrument and procedure
Questionnaires and interviews are used in this study. There are two types of questionnaires: 1) Questionnaires for students and laboratory assistants that are paper-based and online, 2) questionnaires for experts using the Likert scale 1-4. Moreover, interviews were conducted to get a complete picture of the problem and get in-depth information from users and experts. Therefore, the interview protocol is also prepared.

The steps in the developing and assessing of chemical laboratory safety videos use the ADDIE development model, namely, analyze, design, develop, implement, and evaluate [18].

3. Results and discussion

3.1. The problems of learning in chemical laboratories related to the safety lab
The data obtained from the questionnaire and interviews have been analyzed. Based on these data, there is some information related to work safety in a chemical laboratory. Firstly, most students already knew the rules in the chemistry laboratory through the orientation when preparing for practicum, but there are still some students who often look panicked when practicum activities are carried out. Secondly, there are still students who make mistakes and cause accidents during practicum. Violations and mistakes that have been experienced such as: breaking tools (2 students), spilling chemicals (5 students), inhaling chemicals (8 students), being exposed to chemicals on the skin (7 students), and experiencing other violations, for instance, mixing chemicals incorrectly and not following the experiment procedure (5 students). Thirdly, some students do not understand the impact of using chemicals, disposing of waste equipment and chemicals incorrectly, and do not know how to handle mistakes or accidents that occur, such as handling when exposed to chemicals on the skin or the hands.

According to the answers to questions about practicum preparation activities, all students stated that they need to increase chemical laboratory safety knowledge (hazardous chemicals and their handling) before or when carrying out chemical practicum. Overall, students assume that knowing safety at the chemistry laboratory can at least reduce or prevent errors and accidents during practicum. Some students stated that there are things can be done to understand aspects of chemical laboratory safety before carrying out practicum, such as reading the chemical lab guide, looking for more information about chemicals through MSDS (Material Safety Data Sheet), and looking at other references to prepare chemical practicum in the video form on YouTube.

3.2. The feasibility of chemical laboratory safety videos

3.2.1. Video assessment by the experts. In the results of the validation of material and language experts, suggestions for improvement or revision are needed to be addressed in the video section, including on how to pour the solution, writing and displaying examples of chemicals, writing in English, the use of fume hood, the use of small bottles and revision of the contents of the first aid box. The results of the video feasibility based on the results of the validation from the material and language experts are shown in Table 1.
Table 1. The videos feasibility based on the assessment of material and language experts.

| Aspect                      | Indicator                                                                 | item(s) | Average Percentage | Criteria of feasibility |
|-----------------------------|---------------------------------------------------------------------------|---------|--------------------|-------------------------|
| Content and material        | Video compatibility with the practicum guidelines                          | 1, 2    |                    |                         |
|                             | Concept and procedure accuracy                                            | 3, 4, 5 | 98%                | Very good               |
|                             | Accuracy of terms, notations, symbols or icons                            | 6       |                    |                         |
| Video presentation          | Systematic consistency of presentation                                     | 7       |                    |                         |
|                             | Easy to understand                                                        | 8, 9    | 98%                | Very good               |
|                             | Match the duration of the video to the material presented                  | 10      |                    |                         |
| Video role                  | For students                                                              | 11      | 92%                | Very good               |
|                             | For lecturers                                                             | 12      |                    |                         |

Based on technology in education experts validation results, suggestions for improvements in the video are obtained such as the addition of the presenter's name and UNJ logo, the location of the writing and setting of the place, hand movements and background, the color of the writing and lighting, the background color, and the addition of closing and credits. The results of the video feasibility based on the validation results from the technology in education experts are shown in Table 2.

Table 2. The videos feasibility based on the assessment of technology in education experts.

| Aspect             | Indicator                                                                 | item(s) | Average Percentage | Criteria of feasibility |
|--------------------|---------------------------------------------------------------------------|---------|--------------------|-------------------------|
| Visual video       | The composition of colours, images, animations                            | 1, 2, 3 |                    |                         |
|                    | Image clarity                                                             | 4, 5    | 92%                | Very good               |
|                    | Lighting accuracy                                                         | 6       |                    |                         |
|                    | Presenter's appearance                                                    | 7, 8    |                    |                         |
| Audio Video        | Voice clarity                                                             | 9, 10, 11| 95%                | Very good               |
|                    | Music compatibility                                                       | 12      |                    |                         |
| Typography         | Selection of font types                                                   | 13, 14  | 89%                | Very good               |
|                    | Selection of font size                                                    | 15      |                    |                         |
| Programming        | Video duration                                                            | 16      | 91%                | Very good               |
|                    | Video presentation                                                        | 17      |                    |                         |

3.2.2. Video assessment by the users. Based on the results of the video testing by three laboratory assistants and 90 students, a video demonstration of the safety of chemical laboratory work in preparation for a basic chemical practicum that has been developed is very interesting to watch; the presentation is excellent and easy to understand. Students assess that the duration is appropriate, and access to view videos is effortless. The application of chemical laboratory safety videos as the visual media for the preparation of practicum can make students more prepared. This assumption was supported by 92% of students stated that they have a description of conditions and have understood aspects of work safety in a chemical laboratory after seeing the videos of chemical laboratory safety in preparation for basic chemistry lab work. The results of video ratings on users are shown in table 3.
Table 3. The videos feasibility based on the assessment of users.

| Aspect                        | Indicator                                                                 | item(s) | Average Percentage | Criteria of feasibility |
|-------------------------------|---------------------------------------------------------------------------|---------|-------------------|-------------------------|
| Video display presentation  | Video appealing                                                           | 1, 2    | 91%               | Very good               |
| and design                   | Suitability of colour, size, and type of font                             | 3       |                   |                         |
|                               | Ease of video flow to be understood                                      | 4       |                   |                         |
| Programming                  | Accuracy of duration                                                      | 5       | 91%               | Very good               |
|                               | Easiness of access and use                                                | 6, 7, 8 |                   |                         |
| Video role                   | Helping students in basic chemical lab preparation                        | 9, 10   | 92%               | Very good               |

In the design of the model, the chemical laboratory safety videos for the preparation of basic chemistry labs were made into four segments, which lasted about 3-8 minutes. According to one technology expert in education, the ideal duration of a video that will be uploaded to mass media is only a maximum of 5 minutes. However, that could be more than 5 minutes, depends on the content. The four video segments consist of equipment and regulations in the chemical laboratory, introduction of chemical labels, demonstration of working with chemicals, and first aid in handling in the chemical laboratory. After revisions based on assessments and suggestions from experts and users, a series of videos on the chemical laboratory safety for the preparation of basic chemical practicums have been developed and can be seen in Figure 1.

![Figure 1. A video series of chemical laboratory safety.](image)

4. Conclusion
This research produced a series of chemical laboratory safety videos that will be used for the preparation of Basic Chemistry Practicum. Based on the results of the analysis, the results of the assessment and expert input followed by trials to the users, it can be concluded that the video demonstration of the safety of the chemical laboratory work was declared to be appropriate with a very good category, to be used in the preparation of basic chemical practicum.
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