

## Research Article

# The Development of Electronic Modules (E-Module) For Learning Chemical Safety and Security in High School Laboratories

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**ORCID**Muktiningsih Nurjayadi: <https://orcid.org/0000-0003-1666-2263>**Abstract.**

The use of e-learning was very helpful in the distance learning process that was implemented during the COVID-19 pandemic. One of the applications of e-Learning media that can be used is the electronic module (e-Module). The purpose of this study is to develop electronic modules (e-Module) on chemical safety and security in high school laboratories. This study uses a descriptive quantitative method with research and development outlined by Borg and Gall. The instrument used in this study was a questionnaire. The e-Module was validated by experts in media and graphics, and experts in content and language. The e-Module was also tested by chemistry teachers, students in 10th grade, and college students in the chemistry education program. The result from the assessment given by experts, teachers, and students from the validation and trial stage can be interpreted as *well* up to *very good*. It can be concluded that the e-Module is feasible to be used as a learning media of Chemistry on Chemical Safety and Security in High-School Laboratories for high-school students.

**Keywords:** electronic module, chemical safety, security

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## 1. INTRODUCTION

Much of chemistry is experimental science and most of its knowledge is obtained from laboratory research [1]. Therefore, practicum is a very important activity in studying chemistry. Practical activities can make students' understanding of the chemistry taught in class more meaningful, train the use of laboratory equipment, recognize chemicals, and prove existing theories [2]. In carrying out practicum activities, chemical safety and security are very important to be considered in order to smooth the process of practicum activities.

Chemical safety and security in laboratory are important thing to pay attention to because the potential danger in a chemical laboratory can cause work accidents and reduce the quality of a person's life. Potential physical hazards include noise, heat

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stress, ionic and non-ionic radiation, electrical lighting, and fire [3]. The accidents most often experienced by practitioners are contact with heat, exposure to chemical spills, and complaints of feeling dizzy and nauseous due to inhalation of chemicals while conducting experiments [4].

The 2013 curriculum in Indonesia describes new study on chemical safety and security in laboratory for 10th grade high school students. This study is very important to provide knowledge to students at the beginning they are familiar with chemistry so that when doing practical work later can minimize the occurrence of accidents in the laboratory. Learning resources are important in supporting the learning process, including learning about chemical safety and security in high school laboratory. It is important to study chemical safety and security in order to avoid the risk of accidents due to dangerous behaviour and lack of understanding of the properties of chemicals. Students need to be aware of the practice of working safely and also the consequences that can be caused when safety regulations are not followed [5].

The rapid development of technology today has affected all areas of life, including in the field of education. One of the uses of technology in education is electronic learning. e-Learning aims to provide information related to learning materials to students even though it is hindered by the distance between educators and students. e-Learning is a part of distance learning that utilizes electronic technology and the internet to access information related to learning materials [6]. The use of e-Learning is currently very useful in the distance learning process that is being implemented by schools and universities in Indonesia which are affected by the COVID-19 pandemic. This distance learning is carried out to limit the spread of the COVID-19 virus.

Distance learning requires students to learn independently, so learning media is needed to support students to study independently at home. One of the applications of media e-Learning that can be used as independent learning is an electronic module. The electronic module is an independent teaching material that contains information presented in digital format. Electronic module is an electronic version of the module where access and use can be done via computers, tablets, or smartphones [7]. Electronic modules can be accessed via the internet, macromedia flash, java, and other electronic media [8]. The electronic module is a learning resource that matches the expectations of students and is useful in the distance learning process. Electronic modules can help students learn independently and are needed by students as a learning guide [9]. The electronic module can present material interactively through several multimedia such as video, animation, simulation, and questions accompanied by feedback directly [10]. The electronic module is presented systematically [11] so that readers can learn

with or without a teacher or facilitator. The use of electronic modules is very effective in increasing student motivation. Students are not bored with studying due to the students can explore each material using their cell phones only when travels, students are still able to open the electronic module for learning. Because students are motivated to learn, student learning outcomes will also increase [12].

## 2. RESEARCH METHOD

This research was conducted from November 2019 to July 2020. The type of research used in the development of e-Module on chemical safety and security in high school laboratory is the Research and Development (R & D). Research and development in education is an applied process for the development and validation of educational products [13]. The research method used is descriptive quantitative by taking data using a questionnaire. The development of an electronic module on chemical safety and security in high school laboratory uses the research and development stages proposed by Borg & Gall. There are 10 stages of research and development according to Borg and Gall, namely preliminary analysis and needs, planning, development e-Module, validation e-Module by experts, revision of validation results e-Module by experts, small-scale trials, revision of trial results small-scale, large-scale trials, revised results of large-scale trials, and dissemination.

The instrument used was in the form of a preliminary analysis questionnaire and needs validation of e Module by experts, and trials of teachers and students. The preliminary analysis questionnaire needs using the Guttman scale with the type of answer “yes-no” and several open-ended questions. The expert validation questionnaire used a ten-point scale from very bad to very good. The teacher and student trial questionnaire used a Likert scale. The research data were analyzed using the percentage descriptive system [14]. The resulting score is then interpreted, as shown in Table 1.

TABLE 1: Interpretation of percentage.

No.	Percentage	Interpretation
1.	0% - 29%	Very less
2.	30% - 59%	Less
3.	60% - 89%	Good
4.	90% - 100%	Very Good

After the data is processed and interpreted, the reliability of the experts' assessment is calculated using the Hoyt formula.

### 3. RESULT AND DISCUSSION

#### 3.1. Preliminary Analysis and The Needs of Teachers and Students

The preliminary and needs analysis stage was carried out on chemistry teachers and 10th grade students. Data collection at this stage was carried out by distributing a preliminary analysis questionnaire containing questions about the opinions of teachers and students regarding chemical safety and security learning, teaching materials used to study chemical safety and security in high school laboratory as well as problems faced in learning chemical safety and security in high school laboratory. While the needs analysis questionnaire contains questions about the opinions of teachers and students regarding teaching materials that are expected to study chemical safety and security in high school laboratory.

The results and findings obtained from this stage are as many as 53.45% of students do not have basic skills in the laboratory well, such as how to smell gas, heat a solution, pour substances, dilute solutions, and use simple tools in practicum. laboratory. Several teacher and student respondents stated that the source of information used in learning chemical safety and security in high school laboratories was printed books. Teachers and students look forward to interactive, modern, and easy-to-understand resources for learning about chemical safety and security in high school laboratories.

From the results of the preliminary analysis and the needs of teachers and students, it was chosen to develop an electronic module as another teaching material that can be used in learning chemical safety and security learning in high school laboratories. This is because the learning module can help students learn independently [9]. Modules are presented in a systematic way so that readers can learn with or without a teacher or facilitator. In addition, the electronic module is interactive and can contain images, audio, video and animation and is equipped with formative tests/quizzes that can provide direct feedback automatically.

#### 3.2. Planning

This stage begins with the analysis chemical safety and security in high school laboratory, making the storyboard, compiling instruments and determining the parties involved, and selecting the application used to make the e-Module.

The material presented is a development of the basic competencies of the sub-topic of chemical safety and security in high school laboratory based on Permendikbud No.

37 of 2018. These basic competencies are then analyzed on the sub-topic of Chemical Safety and Security in High School Laboratory and divided into three learning activities based on the indicators of achieving the competencies to be achieved, the division is shown in Table 2.

TABLE 2: Competency achievement indicators in the e-module.

Activity on the e-Module	Competency Achievement Indicators
Learning Activities 1 Chemical Laboratory and Personal Protective Equipment	Applying chemical safety and security in high school laboratory. Applying discipline in chemical laboratories Getting used to personal protective equipment (PPE) in laboratory.
Learning Activities 2 Simple Laboratory Tools	Distinguishing various kinds and uses of simple tools chemical laboratories. Know how to use a wide range of chemical laboratory tools. Train basic techniques work in the laboratory.
Learning Activities 3 Hazardous Chemicals and First Aid in Laboratory Accidents	Distinguishing a wide range of harmful chemicals. Predicting hazards and accidents that can occur in chemical laboratories. Knowing first aid in accidents in chemical laboratories.

The results of material analysis obtained from the previous stage are then visualized in the form of a storyboard. Storyboard is a sketch or rough description of the whole or activity of a media before making the original object [15].

### 3.3. Early Product Development E-Module

The development stage of the chemical safety and security in high school laboratory begins with the preparation of materials and questions in word format, collection of images, animations, and videos. Then proceed with the cover design stage and e-Module content as well as layout arrangement using CorelDraw X6 software and the resulting e-Module draft in pdf format. The next step is to convert the draft e-Module in .pdf format into a FlipBook and integrate interactive questions, pop-up images, animations, and videos using the FlipPDF Professional software.

### 3.4. Validation of E-Module by Expert

The initial products are e-Module validated in accordance with eligibility requirements according to the text books are in the component material BNSP and language and presentation and graphics (media). The number of respondents on the validation of e-Module was three people for material and language experts and three people for media experts. The results of the assessment obtained by material and language experts can be seen in Table 3.

TABLE 3: Interpretation of the result of the validation assessment of e-module the material and language component.

No	Indicators	% Assessment	Interpretation
e-Module content components			
1	Material coverage	92.22%	Very good
2	Accuracy of materials	90.00%	Very good
3	Skills	85.00%	Good
e-Module language components			
4	Conformity with the development of learners	85.00%	Good
5	Communicative	80.00%	Good
6	Ability to motivate	88.33%	Good
7	Loss	86.67%	Good
8	Coherence and flow of thought	90.00%	Very good
9	Conformity with Indonesian rules	90.00%	Very good
10	Use of symbol terms	85.00%	Good

The assessment of small-scale trials by students includes five aspects, namely the quality of the material, experiments, and questions; language; audio and visual display; soft intermediary implementation and engineering; as well as the benefits of the e-Module. The results of the interpretation of small-scale student assessment trials can be seen in Table 4.

TABLE 4: Interpretation of the results of the validation assessment e-module media component.

No	Indicators	% Assessment	Interpretation
Cover design			
1	Cover layout	85.00%	Good
2	Cover typography	82.78%	Good
3	Cover illustration	82.22%	Good
Content design			
4	Content layout	83.33%	Good
5	Content typography	82.78%	Good
6	Content illustration	84.17%	Good

Based on reliability calculation results between the rater obtained a reliability value of 0.96 with very good criteria. These results show the consistency of the experts' assessment for each indicator and show that the e-Module chemical safety and security in high school laboratory is appropriate for use in terms of presentation and graphics.

### 3.5. Test E-Module Small Scale

The initial stage of the trial was carried out on a small scale which aimed to get criticism and suggestions from students and teachers. The small-scale trial assessment by the teacher includes five aspects, namely the suitability of the substance of the content with the competencies that students must achieve; quality of material, experiments, and questions; language; audio and visual display; as well as the benefits of the e-Module. The results of the interpretation of the small-scale trial of teacher assessments can be seen in Table 5.

TABLE 5: Interpretation of the results of the trial e-module by teachers on a small scale.

No	Aspects	% Assessment	Interpretation
1	Conformity of content substance with competencies that must be achieved by students	90.00	Very good
2	Quality of materials, experiments, and problems	90.48	Very good
3	Language	87.50	Good
4	Audio and visual display	83.33	Good
5	Benefits	86.11	Good

The assessment of small-scale trials by students includes five aspects, namely the quality of the material, experiments, and questions; language; audio and visual display; soft intermediary implementation and engineering; as well as the benefits of the e-Module. The results of the interpretation of small-scale student assessment trials can be seen in Table 6.

TABLE 6: Interpretation of the results of the trial e-module by students on a small scale.

No	Aspects	% Assessment	Interpretation
1	Quality of materials, experiments, and problems	86.56	Good
2	Language	83.75	Good
3	Audio and visual display	87.50	Good
4	Software implementation and engineering	85.42	Good
5	Benefits	81.61	Good

Based on the results of the interpretation of the assessment by teachers and students in small-scale trials, it shows that the e-Module chemical safety and security in high school laboratory is classified as good to very good.

### 3.6. Test E-Module Large Scale

The e-Module that was tried out by students and teachers on a small scale and improved was then tried again by students and teachers on a large scale. This trial is the final stage which aims to get criticism and suggestions from students and teachers in a greater number of respondents so that an e-Module of chemical safety and security can be produced in a ready-to-use high school laboratory. The results of large-scale interpretation of teacher assessments can be observed in Table 7 and the results of large-scale interpretation of student assessments can be observed in Table 8.

TABLE 7: Interpretation of the results of the trial e-module by teachers on a large scale.

No	Aspects	% Assessment	Interpretation
1	Conformity of content substance with competencies that must be achieved by students	90.83	Very good
2	Quality of materials, experiments, and problems	91.07	Very good
3	Language	87.50	Good
4	Audio and visual display	86.45	Good
5	Benefits	88.19	Good

TABLE 8: Interpretation of the results of the trial e-module by students on a large scale.

No	Aspects	% Assessment	Interpretation
1	Quality of materials, experiments, and problems	84.56	Good
2	Language	84.50	Good
3	Audio and visual display	85.00	Good
4	Software implementation and engineering	84.25	Good
5	Benefits	80.83	Good

Based on the results of the interpretation of the assessment by teachers and students in large-scale trials, it shows that the e-Module chemical safety and security in high school laboratory is classified as good to very good. so that the e-Module developed is suitable for use as a learning medium in implementing chemical safety and security learning in high school laboratories.

Students think that the presentation of e-Modules is very interesting to read both from the color selection, writing style and illustrations presented. The material presented in the e-Module is also clear and easy to reach. The addition of interactive videos, pictures, and practice questions can foster interest and increase students' understanding in studying chemical safety and security in the high school laboratory. This is in line with



Azhar's statement, increasing visualization in the form of images or videos in learning media can foster student interest in learning the material [16]. Some students also got the opinion that e-Module is very suitable for use during the COVID-19 pandemic which can help students to learn independently from home in the distance learning process. This is in accordance with research conducted by Rosa that the module really helps students to learn independently, helps and is needed by students as a study guide [9].

The developed E-Module is available in online and offline formats. In the online format, there are problems accessing the e-Module. e-Module that is presented online requires a stable internet network so that loading the next page will take a long time if the available network is unstable. However, the e-Module that is presented online has the advantage that it can be accessed via a smartphone while the e-Module that is presented offline can only be accessed with a PC or laptop but does not require an internet network. The disadvantage of the developed e-Module is that there is no highlighter feature for sections that students want or consider important and note features for taking notes in the e-Module.

## 4. CONCLUSION

The electronic module for learning chemistry on chemical safety and security in high school laboratory was developed based on the research and development method of Borg and Gall. The results of the e-Module assessment obtained from material and language experts, media experts (presentation and graphics), and users (teachers and students) are categorized as good to excellent with a value range of 80.00% - 92.22% on the material, language, and presentation. Then, the reliability test of the expert's judgment also shows that the assessment is consistent with a reliability value of 0.94 for material and language experts and for 0.96 media experts (presentation and graphics).

Students think that the presentation of e-Modules is very interesting to read. The addition of interactive videos, pictures, and practice questions can foster interest and increase students' understanding in studying chemical safety and security in high school laboratory. Some students also got the opinion that e-Module is very suitable for use during the COVID-19 pandemic which can help students to learn independently from home in the distance learning process.

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