Vol 12 (1), 2023, 1-12 DOI: 10.23960/jppk.v12.i1.2023.01
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-**ISSN 2302-1772**
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

Develompment of Web-Based Interactive e-Module to Improve the Ability to Symbolically Represent on Chemical Bonding Materials

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Received: February 27th, 2023 *Accepted : March: 15*th, 2023 *Online Published:* April 25th, 2023

Abstract: Develompment Of Web-Based Interactive E-Module to Improve The Ability to Symbolically Represent on Chemical Bonding Materials. Chemical bonds are one of the abstract chemistry materials in high school. This is because when studying chemical bonds, students cannot observe directly how the original forms of ions, atoms and bonds occur. Students can understand chemical bond material when they have symbolic representation abilities, so teaching materials are needed that can support students' symbolic representation abilities, one of which is e-modules. The purpose of this study is to describe the feasibility of the e-module. This study used the Research & Development model with data analysis techniques, descriptive analysis and the Wilcoxon test. The results of the expert validation show that nine indicators on content validity, eleven indicators on construct validity, and seven indicators on the readability test all get valid categories. the practicality of the module reached a value of 95.5%, while the analysis of the effectiveness of the e-module used the Wilcoxon test because the data was not normally distributed, the Asymp.Sig.(2-tailed) value was 0.005. The conclusion is that this web-based interactive e-module on chemical bond material can be said to be feasible.

Keywords: e-module, web, symbolic representations.

Abstrak:Pengembangan E-Modul Berbasis Web untuk Meningkatkan Representasi Simbolik pada Materi Ikatan Kimia. *Ikatan kimia merupakan salah satu materi kimia di SMA yang bersifat abstrak. Hal ini dikarenakan ketika mempelajari ikatan kimia, peserta didik tidak dapat mengamati secara langsung bagaimana bentuk asli ion, atom, dan ikatan yang terjadi. Peserta didik dapat memahami materi ikatan kimia ketika memiliki kemampuan representasi simbolik, maka diperlukanlah bahan ajar yang dapat menunjang kemampuan representasi simbolik bagi peserta didik, salah satunya adalah e-modul. Tujuan dari penelitian ini adalah untuk mendeskripsikan kelayakan e-modul. Penelitian ini menggunakan model Research & Development dengan teknik analisis data modus, analisis deskriptif dan uji wilcoxon. Hasil validasi ahli menunjukkan sembilan indikator pada validitas isi, sebelas indikator pada validitas konstruk, dan tujuh indikator pada uji keterbacaan semuanya mendapatkan kategori valid. kepraktisan modul mencapai nilai 95.5%, sedangkan analisis keefektifan e-modul digunakan uji wilcoxon karena data tidak berdistribusi normal didapatkan nilai Asymp.Sig.(2-tailed) 0,005. Kesimpulannya adalah e-modul interaktif berbasis web pada materi ikatan kimia ini dapat dikatakan layak.*

Kata kunci: *e-modul, web, representasi simbolik..*

▪ INTRODUCTION

Chemical bonding are one of the chemistry subject matter in high school. Chemical bonding in chemistry include basic but are complex. Chemical bonding is a material that often causes learning difficulties, misunderstandings, and misconceptions (Georgios Tsaparlis, Eleni T, 2014). Chemical bonding is also a fundamental idea in chemistry. Other subjects covered in chemistry curricula heavily rely on ideas and models of chemical bonding (Anekwe, Christoper Ejike & Opara, 2021).

According to students, chemical bonding are quite difficult material, this is reinforced by pre-research data, namely teacher interviews conducted at a high school in the Surabaya area stated that chemical bonding are included in quite difficult material, the majority of difficulties experienced by students are concepts. regarding the differences in the formation of ionic bonds and covalent bonds, determining what molecular formulas are formed when two or more elements form bonds, and determining the polarity of covalent compounds. Material on chemical bonding is abstract because basically students cannot see atoms, cations, anions, even the forms of bonds (Ridlo & Novita, 2019). Because of this, students must have multi-representational abilities, one of which is symbolic representation ability (Sukmawati, 2019). In chemistry lessons, the ability to multirepresentation is essential to describe chemical concepts that are abstract and cannot be seen by the naked eye (Rodić et al., 2018). Despite the fact that symbolic statements are crucial for knowledge production, they are a source of learning challenges in chemistry education (Liu & Taber, 2016). The ability of symbolic representation in students affects their problem solving in chemistry learning (Graulich, 2015). When students have good symbolic representation abilities, students can transfer theory into symbolic forms such as dots to symbolize electrons in atoms, one line symbol to represent a single bond, two line symbols to symbolize a triple bond and so on. When students have this ability, their understanding of chemical material becomes better (Zahro' & Ismono, 2021). Therefore chemical bonding material requires teaching materials that can support students' symbolic representation abilities (Anekwe, Christoper Ejike & Opara, 2021)

Digital learning tools & materials are continuously being developed to support effective learning (Kiernan, Manches dan Seery, 2021). Technology plays a very important role in making effective teaching materials for students (Hutabarat, Sanova dan Syamsurizal, 2021). One of the teaching materials is a module, a module is a teaching material that is packaged as a whole and systematically, the module contains a set of learning experiences that are planned and designed to help students with specific learning goals. The module contains at least three components, namely learning objectives, learning materials, and evaluation. The module functions as an independent learning tool (Daryanto, 2013). E-Module is an alternative teaching material replacing printed module. E-module are presented in an electronic format and the learner's activities in them are connected by links. E-module can be accessed using computers or mobile phones (Junita & Sukardi, 2020). E-module has a great opportunity to be interactivated, E-module has several advantages, namely not heavy when carried anywhere regardless of the number of pages, E-module can be equipped with features that can support students' understanding, these features include e-module animation features, both animation as decoration and animation as an explanatory concept, enlarged concept explanatory images, links directly connected to interactive worksheet that can be done directly by learners, and evaluation questions that can be done directly on the web after working on studying the e-module.

The Web is that part of the Internet that consists of pages that can be accessed by a Web browser (Achmad Ali Fikri, Syamsul Arifin, 2022). People have used the web extensively to access various types of information (Pratiwi et al., 2020). The advantages of the website as a learning tool are that it allows students to access it anytime and from any location, it is more attractive to students' learning interests and more effective, relatively low cost, easy to implement, and most importantly contains lots of useful features (Oktaviani & Ayu, 2021). Because of this, the web is very suitable to be used as a means of making teaching materials, one of which is e-module. Web-based e-module has features that can facilitate symbolic images needed to facilitate students' symbolic representations (Huda & Dwiningsih, 2021).

Pre-research data, namely an interview with a chemistry teacher at a high school in Surabaya that chemistry teachers are very interested in and support the use of web-based learning media, besides that, almost all teachers and students have smartphones or personal computers. The majority of teachers and students are also used to and proficient in using websites both when opened via smartphones or personal computers.

Based on this background, the researchers wanted to create a web-based interactive e-module on chemical bonding materials.

▪ METHOD

This type of research is Research & Development (R n D). Reseach and Development (R & D) has the aim of finding, developing and validating a learning product (Sugiyono, 2015).

Research Subject

The subject of this study is a web-based e-module on chemical bonding materials.

Procedures

This study used the ADDIE model (analysis, design, development, implementation, evaluation) (Branch, 2009). However, because this research is a development research, the stage carried out only reaches the development stage.

The analysis stage is the stage where the researcher analyzes the need for developing teaching materials in the learning process, some of the analyzes carried out are performance analysis, student analysis, fact analysis, and learning objectives analysis. In performance analysis, the developer analyzes the problems encountered in the learning process. In students analysis, the developer analyzes the characteristics of students in the cognitive domain and the skills of students to operate mobile phones or personal computers. In this analysis. In the analysis of the goals of the developer will analyze the achievement or learning objectives that need to be achieved by students.

At the design stage the researcher will plan the preparation of teaching materials based on the analysis carried out by the developer, create storyboards in the form of teaching material designs to be developed, plan learning scenarios, select teaching material competencies, plan learning devices, design learning materials and learning evaluation tools. This design and planning is of course always accompanied by an evaluation by experts and revisions are made if necessary.

At the development stage, the researcher realizes the product design, in this case, the learning material. At this step, the learning material must be ready, then evaluated by experts and revised periodically. The finished e-module was then validated by two expert lecturers and one chemistry teacher. After obtaining validity, the e-module will then be tested on a limited basis to measure its practicality and effectiveness.

Research instrument

The research instrument used is a validation sheet, questionnaire sheets, and pretest posttest questions. The validation sheet is used to obtain a validity assessment. Validity refers to the suitability and correctness of the e-module that has been created. there are three aspects on the validation sheet, namely content validity, construct validity, and readability test. The questionnaire sheet is used to determine the practicality of the e-module, while the pretest posttest is used to determine the effectiveness of the e-module.

Collecting data Method

The data collection method is a questionnaire.

Data Analysis Techniques

This data analysis technique is used to determine the validity of the e-module that has been developed. The assessment questionnaire was measured using a likert scale which consisted of five selected categories:

Table 1. Likert scale description

Likert Scale	Description
1	Very good
2	Good
3	Enough
4	Not good
5	Not very good

(Riduwan, 2008)

Because the data generated on the measurement includes ordinal data, the analysis of the validation data is carried out by determining the mode at each validated point, with the condition that the decision making is as follows: If the mode ≥ 3, then the point is declared valid while, if the mode < 3 then the point is declared invalid and must be revised (Adoption Lutfi, 2021).

Data analysis techniques to measure the practicality of this e-module use descriptive analysis with the help of SPSS or Microsoft Excel software, along with the score for each statement answer:

Table 2. Score for a favorable answer

Question answers	Score
Yes	1
No	0

Table 3. Score for a unfavorable answer

Question answers	Score
Yes	0
No	1

To determine the level of practicality of the e-module, the following formula is used:

$$Practicality\ level = \frac{Score\ average}{maximum\ score}\ x\ 100\ \%$$

Table 4. Practically Level Classifification

Precentage	Criteria
$0 \leq x < 21$	Not practical
$21 \leq x < 40$	less practical
$41 \leq x < 60$	Practical enough
$61 \leq x < 80$	Practical
$81 \leq x < 100$	Totally practical

(Riduwan, 2008)

Based on the table, the e-module is said to be practical if the percentage is ≥61%

The data analysis technique to measure the practicality of the e-module is as follows:

1) Normality Test

The normality test is a testing method in statistics that is used to find out whether a data is normally distributed or not. In this study the Shapiro Wilk test was used because the amount of data is not more than 50. The normality test uses a tool in the form of SPSS on the basis of decision making, if the Sig value> 0.05 then the data is normally distributed, whereas if the Sig value <0.05 then the data is not normally distributed.

2) t test (paired sample t test)

The t test will be carried out if the data is proven to be normally distributed. The t test is used to find out whether there are differences in the average pretest and posttest scores in the experimental class, so that the effectiveness of the e-module can be determined.

- Submission of hypotheses
  H_0 : There is no difference in the average students' symbolic representation abilities for the pretest and posttest
  H_1 : There is a difference in the average symbolic representation abilities for the pretest and posttest
- Determination of basis for decision making
  If the value of Asymp.Sig. (2-tailed) < 0.05, then H_0 is rejected
  If the value of Asymp.Sig. (2-tailed) > 0.05, then H_0 is accepted

3) Wilcoxon test

If the data is not normally distributed, the data analysis technique used is non-parametric statistics, namely the Wilcoxon test.

- Hypothesis submission
  H_0 : There is no difference in the average students' symbolic representation abilities for the pretest and posttest
  H_1 : There is a difference in the average symbolic representation abilities for the pretest and posttest
- Basis for decision making:
  If the value of Asymp.sig.(2-tailed) < 0.05, then H_0 is rejected.
  If the value of Asymp.sig.(2-tailed) < 0.05 then H_0 is accepted.

(Lubis et al., 2017)

▪ RESULT AND DISCUSSION

At the analysis stage the developer conducted field studies with the following results : 1) The results of an interview with a chemistry teacher at a school in Surabaya

stated that the teaching materials commonly used for the learning process were textbooks and worksheet. 2) The results of interviews with chemistry teacher at a school in Surabaya stated that chemical bonding are relatively difficult material, especially in the concept of defining ionic bonds and covalent bonds, determining what molecules are formed when several elements bond, and determining the polarity of a molecule. 3) The results of the questionnaire to 23 students, 56.5% stated that chemical bonding material was classified as quite difficult material 4) The results of the questionnaire and observation of 23 students stated that the majority brought smartphones or personal computers at school, they had a good internet connection , and already familiar with the web. 5) The results of interviews with chemistry teachers stated that they were very interested in and supported the use of teaching materials in the form of module on chemical bonding material.

At the design stage In accordance with the analysis of field studies where the majority of students have *smartphones* or *personal computers*, this e-module is designed to be opened in *smartphone* or *personal computer*. This e-module is designed using WordPress which is integrated with Moodle. Several plugins on WordPress are used to design this page, such as the generate press plugin,Elementor Pro, & QSM. The following is a web-based interactive e-module design on chemical bonding material:

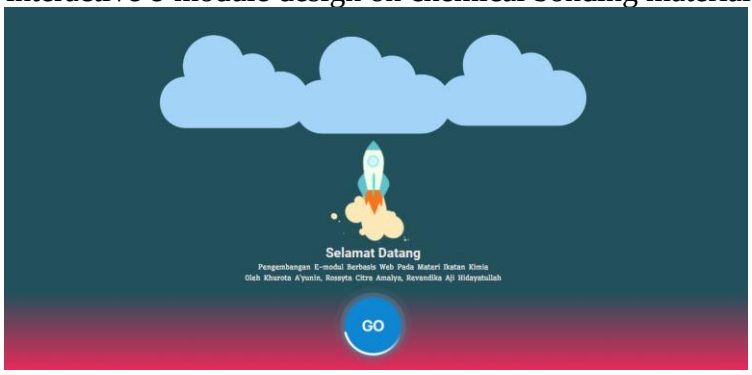
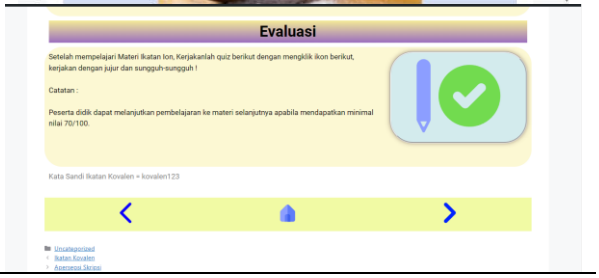


Figure 1. The front page of web-based interactive e-module

Figure 2. E-module table of contents page

The designs made are then evaluated by expert lecturers. The e-module design then gets input and suggestions. The researcher then revised the e-module design with the following results:

Table 5. Revision table of e-modul review results

No.	Sugestion	Revised Result
1	Every time students enter the next step in the e-module, the password is so that students can study the e-module in an orderly, thorough and systematic manner.	
2	The icons in the chemical bond sub-matter are endeavored to use images that are appropriate to the material.	
3.	Each learning activity is added learning objectives and phenomena.	
4.	Each page is added navigation buttons.	

At the development stage, the storyboard that has been made will be realized and made using wordpress and using the elementor, elementor pro, and QSM plugins. After the interactive e-module has been made, the e-module is tested for validity. The following are the results of the web-based interactive e-module validity test:

Table 6. Results of e-module validation

No.	Indicators	Mode	Category
	Content Validty		
1.	Web based interactive e-module developed is relevant (content validity) is good in facilitating the achievement of Indicators symbolic representation.	4	valid
2.	Web based interactive e-module developed suitably with main	5	valid

No.	Indicators	Mode	Category
	competencies and basic competencies.		
3.	Web based interactive e-module developed suitably concept and definition.	5	valid
4.	Web based interactive e-module developed have examples and practice questions that clarify concepts.	5	valid
5.	Web based interactive e-module developed presents the concept and accurate definition.	4	valid
6.	Web based interactive e-module developed presents examples and accurate questions.	4	valid
7.	Web based interactive e-module developed contains examples, descriptions or practice questions that can be demanding students to provide answers or various settlement strategies.	4	valid
8.	Web based interactive e-module developed contains examples or questions that encourages students to get more information from various other sources.	5	valid
9.	Web based e-module developed contains examples that accompanied by explanations or questions equipped with an answer key.	5	valid
	Construct Validity		
1.	Web based interactive e-module developed using grammar appropriate language and spelling good Indonesian rules.	4	valid
2.	Web based interactive e-module developed using language easy to understand.	4	valid
3.	Web-based interactive e-module using coherent language (between sentences and between paragraphs)	4	valid
4.	Web based interactive e-module developed using terms and the appropriate punctuation refined spelling.	4	valid
5.	Web based e-module developed using appropriate chemical symbols (subscripts and superscript).	4	valid

No.	Indicators	Mode	Category
6.	The term used in the web based interactive e-module developed is consistent.	4	valid
7.	Selection of design size and text color on the web-based interactive e-module integrated already.	4	valid
8.	Font, text color, background, and images on a web-based e-module developed is aligned.	5	valid
9.	Web-based interactive e-module has images and text that can be read properly.	5	valid
10.	Web-based interactive e-module has appropriate images and text.	4	valid
11.	Web based interactive e-module developed by presenting examples of questions, practice questions, answer keys, glossary, bibliography, and summary.	5	valid
	Readibility Test		
1.	Web-based interactive e-module has a clear description of the material	5	valid
2.	Web-based interactive e-module is easy for students to use for independent learning.	4	valid
3.	Web-based interactive e-module has examples of questions that clarify the material.	4	valid
4.	Web-based interactive e-module has images that match the material presented.	5	valid
5.	Web-based interactive e-module has practice questions that are easy to understand	4	valid
6.	The web-based interactive e-module has an easy-to-understand formative test	4	valid

The validation results from two expert lecturers and one chemistry teacher stated that the nine indicators on content validity, eleven indicators on construct validity and six indicators on the readability test all had valid categories and did not need to be revised. Then the web-based interactive e-module on chemical bond material is declared valid.

Limited trials were conducted on ten students of class XI MIPA. They did learning about chemical bonds using interactive web-based e-modules, the results were that they were active enough to do so, this was evidenced by their active participation in answering in discussion forums, there were three discussion forums in the e-module. each discussion forum provided was answered on average by 83% of the trial students. For quizzes, each learning activity is also carried out by all test students. This quiz consists of ten multiple choice questions, students can immediately see the value and discussion of the questions

after collecting the quiz. In ionic bond learning activities, the average quiz score is 89, in covalent bond learning activities the average quiz score is 89.1, and in metal bond learning activities the average quiz score is 78.9.

Students are then given a response questionnaire to assess web-based interactive e-modules. The results obtained are as follows:

Table 7. The results of the student response questionnaire

Rated aspect	Percentage	Criteria
Students' understanding of the material	92	Totally practical
Ease of use e-module	92	Totally practical
Clarity of use e-module	99	Totally practical
Language quality	100	Totally practical

From the table it can be concluded that the web-based interactive e-module has a very practical category with an overall practicality value of 95.5%.

To measure the effectiveness of the e-module, the results of the pretest and posttest values are used. First, the students' pretest and posttest scores were tested for the distribution of the data using the normality test with the help of SPSS software.

Table 8. Test results for the normality of pretest and posttest values

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	class	Statistic	df	Sig.	Statistic	df	Sig.
scoreprepo	pretest	.274	10	.032	.795	10	.013
	posttest	.329	10	.003	.655	10	.000

The sig value <0.05 was obtained so that it could be concluded that the pretest and posttest data were not normally distributed, so the next step was analysis using non-parametric statistics, namely the Wilcoxon test.

Table 9. Table of Wilcoxon Test Results

	posttest - pretest
Z	-2.814[b]
Asymp. Sig. (2-tailed)	.005

Asymp value is obtained. Sig. (2-tailed) on the Wilcoxon test is 0.005. It means the value of Asymp. Sig. (2-tailed) < 0.05 so that there is a difference in the average pretest and posttest scores. In conclusion, this e-module can be said to be effective and ready to use for learning activities on chemical bonding material.

▪ CONCLUSION

The results of the validation by two expert lecturers and one chemistry teacher stated that the nine indicators on content validity, eleven indicatord on construct validity, and six indicators on the readability test were in the valid category and no revision was needed. The results of the practicality test of the e-module are said to be valid with an average percentage of 95.5%. The results of the effectiveness test using the Wilcoxon test obtained an Asymp.Sig.(2-tailed) value of 0.005. The conclusion is that this web-based

interactive e-module on chemical bonding material can be feasible (valid, practical, and effective).

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