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# Development of E-Modules Based on 5E Instructional Models in Chemistry

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**Abstract:** Information technology in education opens up new opportunities to enhance learning in schools. The learning media that can be used is e-module, which is an interactive and flexible digital learning resource. This study aimed to develop an e-module based on the 5E instructional model in class XI chemistry at SMA. The development method used is 4D. Identify the needs and objectives of class XI chemistry learning. Furthermore, the structure and content of the e-module is prepared based on the 5E instructional model, namely: engage, explore, explain, elaborate, and evaluate. At the development stage, the e-module is designed and developed by taking into account the principles of instructional design that are in accordance with the characteristics of learning chemistry. E-modules are also equipped with multimedia, interactive simulations, practice questions, and automatic assessments to facilitate interactive learning. After the e-module has been developed, the implementation phase is carried out by testing the e-module in a sample group of class XI students in a high school. Furthermore, an evaluation of the effectiveness of the e-module was carried out through collecting data from students and teachers regarding the use, use, and satisfaction of the e-module. The results of this study are expected to improve the quality of high school chemistry learning, helping students be more active, creative, and independent in understanding complex chemical concepts. With the use of this e-module, learning is expected to be more interesting, interactive, and effective in achieving learning objectives

**Keywords:** Chemistry; E-module; 4D development; 5E instructional model

## Introduction

The phenomenon of the Industrial Revolution 4.0 influences and raises various demands in all aspects of life. This happens because there is a demand that life becomes faster and more practical. All forms of these updates can be felt at this time, such as the emergence of various devices (gadgets), the application of the internet as a whole, and so on. This phenomenon also affects aspects of education that demand upgrades in the field of education, such as the use of the internet in learning, the use of various learning media, the use of learning aids, and so on (Doringin et al., 2020).

This research focuses on the development of e-modules based on the 5E instructional model in chemistry class XI in high school. Chemistry subjects, especially solubility and solubility products at the XI grade level, have complex material and require an appropriate learning approach to help students understand chemical concepts in depth. Therefore, using e-modules integrated with the 5E instructional model approach is expected to improve the quality of chemistry learning and strengthen student understanding (Duran et al., 2004).

The 5E instructional model approach consists of five stages, namely engage (invite students to actively participate in learning), explore (encourage students to explore chemical concepts through various activities), explain (help students understand concepts systematically), elaborate (develop student understanding). Through the application and application of concepts in real situations), and evaluate

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(assessing student learning progress). The integration of e-modules with the 5E approach is expected to provide a more holistic learning experience, strengthen students' conceptions, and improve metacognitive skills (Bybee, 2014).

The purpose of this research is to develop e-modules that meet the needs of chemistry class XI at SMA, as well as to measure the effectiveness and use of e-modules in the learning process. In the development of e-modules, instructional design principles that are in accordance with the characteristics of chemistry learning are used to develop relevant content, multimedia, and evaluation (Herawati et al., 2018).

The introduction of e-modules based on the 5E instructional model in chemistry learning in high school is expected to make a positive contribution in creating a more interactive learning atmosphere, stimulating creativity, and helping students to learn independently. The success of using this e-module can be measured through evaluation and feedback from students and teachers regarding the effectiveness and satisfaction in using it (Mortimer, 2010).

In order to improve the quality of education, especially in chemistry learning, this research is expected to make a significant contribution to the use of technology in education and provide guidance for curriculum developers and teachers in utilizing e-modules based on the 5E instructional model as an effective tool in the chemistry learning process. at the high school level (Desouza, 2017).

## Method

The type of research that will be used in this development research is Research and Development (R and D). According to Sugiyono (2017) "research and development serves to validate and develop products". Developing products in a broad sense can be in the form of updating existing products so that they become more practical, effective and efficient or creating new products (which previously existed)(Sugiyono, 2017).

The development model used in this study is the 4-D development model. according to Thiagarajan, suggests the 4-D development model has four stages, namely Define, Design, Develop, and Disseminate (Lawhon, 1976). The data collection techniques of this research include:

*Validity Test Analysis*

Data obtained from experts were analyzed using media quality criteria and used as a developed learning media. The results of the assessment by experts are processed using Aiken's V statistics as follows (Azwar, 1997):

$$V = \frac{S}{[m(c-1)]} \quad (1)$$

Information: V = validity score, S = ∑s (s = r-lo), Lo = the lowest validity rating score, R = the number given by an appraiser, C = the highest validity rating score, and M = number of items.

The value of V obtained is then interpreted into a validity classification as shown in the following table.

**Table 1.** Validation Criteria (Azwar, 1997)

| Achievement Level | Category |
|---|---|
| 0.667-1.00 | Valid |
| < 0.667 | invalid |

*Practicality Test Analysis*

Practicality analysis was carried out after all questionnaires were filled out. This practicality analysis is used to analyze the observed data using e-modules based on the 5E Instructional Model. The data from filling out the questionnaire will then be added up and analyzed using the formula proposed by (Riduwan, 2012).

$$P = \frac{R}{SM} X\ 100\% \quad (2)$$

Information: P = practicality value, R = score obtained, SM = maximum score.

*Effectiveness Test Analysis*

According to Syafril (2010) the effectiveness formula used to test the descriptive hypothesis is to use a formula with the following steps:

a) d = pre test score – post test score
b) Calculates the mean difference

$$M_D = \frac{\sum d}{N} \quad (3)$$

c) Calculating using the t formula:

$$t = \frac{M_d}{\sqrt{\frac{\sum x^2 d}{N(N-!)}}} \quad (4)$$

Information: Md = the mean of the difference between pretest and posttest, $\sum x^2 d$ = the sum of the squared deviations, N = number of samples.

The results of these calculations are then compared with the t-table. If the results of t-count <t-table, it can be concluded that there is no significant difference between the pre-test and post-test values, and vice versa.

## Result and Discussion

The process of developing e-modules based on the 5E Instructional Model in the Chemistry subject requires systematic and directed procedures so that the development process carried out is carried out properly and is fit for purpose. The e-module development process uses a 4-D research model with four main stages, namely, define, design, develop and disseminate.

*Definition Stage (Define)*

The purpose of this stage is to emerge and determine the basic problems encountered in learning Chemistry so that it requires the development of learning media.

*a) Curriculum Analysis*

Learning media is closely related to the curriculum. In designing a media, it is necessary to analyze the curriculum so that the learning media that will be made can be in accordance with the objectives.

*b) Student Analysis*

Analysis of students in designing learning media was carried out to determine student characteristics and the development of e-modules based on the 5E Instructional Model in Chemistry subject according to the research subject, namely class XI students at SMAN 5 Padangsidimpuan.

*c) Concept Analysis*

Concept analysis aims to identify, detail, and systematically arrange relevant concepts. This analysis is the basis for compiling the objectives of the study.

*Design Stage (Design)*

After conducting various analyzes of the curriculum, analysis of students, analysis of concepts. Researchers began to carry out the media design stage which was intended for class XI students in Chemistry subject.

*a) Compiling Criterion Tests*

Develop criteria and evaluation instruments that will be used to measure students' understanding and achievement of learning objectives. The preparation of this criterion test is a critical step in ensuring that the developed e-module can effectively evaluate students' understanding of chemical concepts.

*b) Choose Learning Media*

The selected media format is one that meets the criteria of being attractive, facilitating and assisting in the learning process. In chemistry subjects, there is a lot of material that displays visual images so that students can better understand the material provided. The previous media format was only in the form of presentations which were only dominated by writing and giving material from books. Based on this, the use of Android can be used to apply e-module learning media based on the 5E Instructional Model in the chemistry learning process in class and outside the classroom.

*c) Preliminary Design (Making media)*

This design is the next step in e-module development, in which a comprehensive lesson plan is designed based on the 5E instructional model. This process involves designing learning steps that include Engage, Explore, Explain, Elaborate, and Evaluate. The following are the steps taken in the Design stage:

*1) Engagement*

The engagement stage is the stage of introducing the solubility sub-material and the solubility product by providing motivation in the form of discourse in everyday life and conveying the GPA that students want to achieve. An example of the engagement stage can be seen in the image.

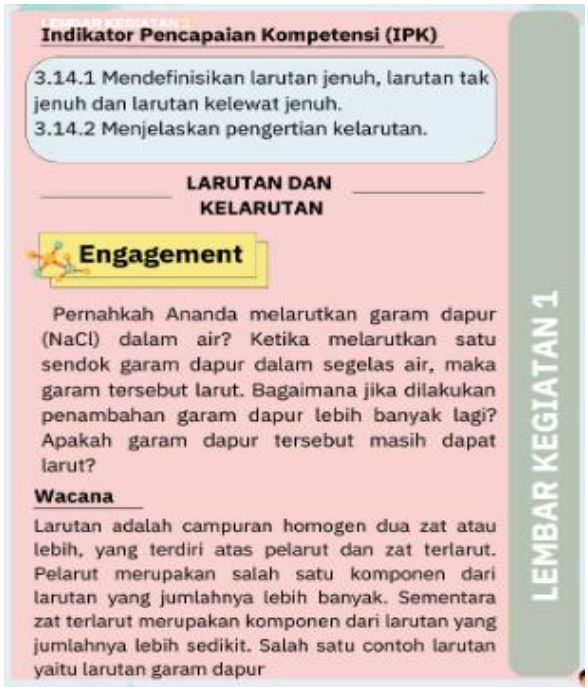


**Figure 1.** Example display on engagement stage

*2) Exploration*

The exploration stage is the stage for students to explore and collect information from various sources. At this stage students are given a summary of material, pictures, and explanatory videos to help students find concepts. An example of the exploration stage can be seen in the picture.

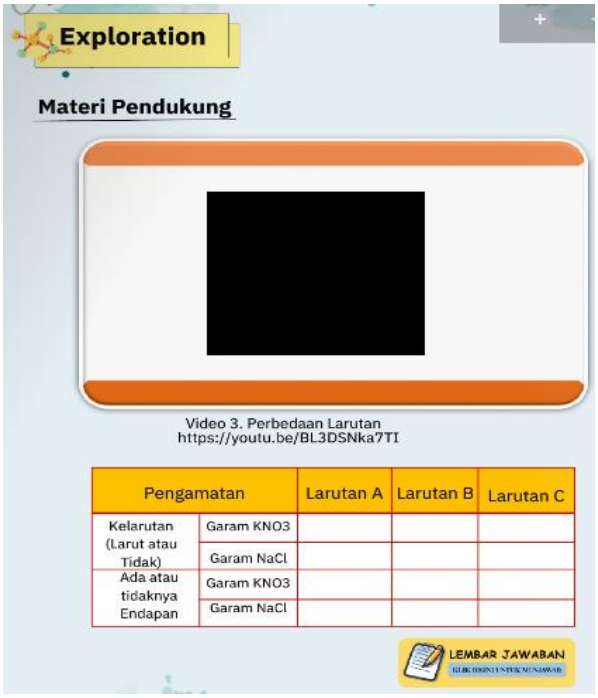


**Figure 2.** Example of the exploration stage display

*3) Explanation*

The explanation stage is a stage for students to explain the concept of learning material after doing tapan exploration. An example of the exploration stage can be seen in the picture.

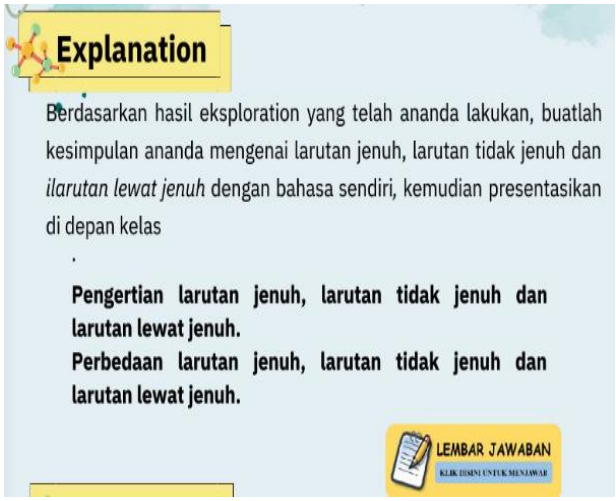


**Figure 3.** Example of explanation stage display

*4) Elaboration*

The elaboration stage is the collaborative stage between students and teachers. The teacher confirms the students' understanding by giving practice questions, then the teacher holds discussions with the students if there is still material that the students have not understood. An example of the display of the elaboration stage can be seen in the picture.

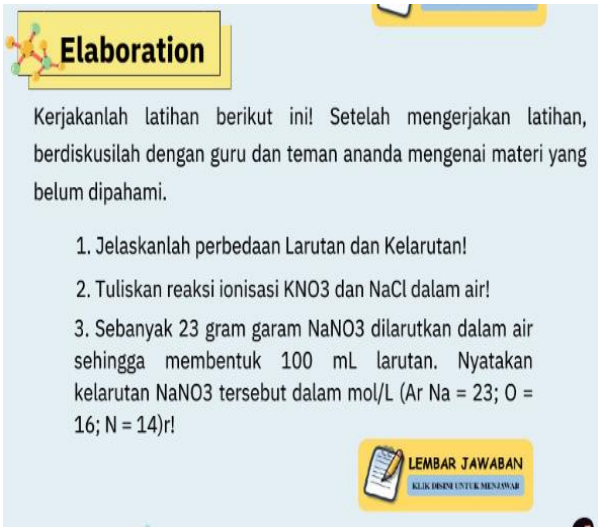


**Figure 4.** Example of the elaboration stage display

*5) Evaluation*

The evaluation stage is the stage to ensure students understand the learning material. For example, by concluding learning material, making portfolios, quizzes, exams, or writing assignments. An example of the display of the evaluation stage can be seen in the picture.

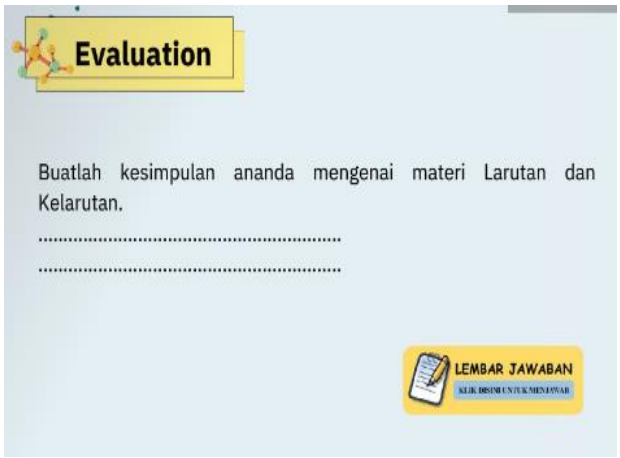


**Figure 5.** Example of the evaluation stage display

*Development stage (Development)*

*a) Validity Test*

*1) Media Validity*

The media expert validity test was carried out with postgraduate lecturers at Padang State University who are experts in the media. At this stage, the researcher shows the media that has been made then media experts provide suggestions and comments. The results of the media expert's assessment are shown in the following table.

**Table 2.** Results of Media Expert Validation Assessment

| No | Aspect | Validity Score | Category |
|---|---|---|---|
| 1 | Media Components | 0.83 | Valid |
| 2 | Media Content | 1 | Valid |
| 3 | Interface | 0.90 | Valid |
| 4 | Interactivity | 1 | Valid |
| 5 | Technology | 1 | Valid |
| V average value | | 0.94 | Valid |

*2) Material Validity*

Material expert validation data was obtained from a material expert, namely a class XI chemistry teacher at SMA Negeri 5 Padangsidimpuan. Material experts examine the material aspects of the e-module based on the 5E Instructional Model that has been designed. The results of the assessment include the components of content, language, presentation and graphics. The results of the material expert's assessment are shown in the following table:

**Table 3.** Results of Material Expert Validation Assessment

| No | Aspect | Validity Score | Category |
|---|---|---|---|
| 1 | Content Components | 0.88 | Valid |
| 2 | Language | 0.95 | Valid |
| 3 | Presentation | 0.87 | Valid |
| 4 | Graphics | 0.78 | Valid |
| V average value | | 0.87 | Valid |

3) *Language Validity*

Validity data was obtained from a linguist, namely a lecturer in the Indonesian Language Study Program, Faculty of Languages and Arts, Padang State University by providing a questionnaire with an assessment sheet. Linguists examine the language aspects of the e-module based on the 5E Instructional Model that has been designed. The results of the assessment include language rules, sentence suitability, and students. The results of the linguist's assessment are shown in the Table 4.

**Table 4.** Results of Language Expert Validation Assessment

| No | Aspect | Validity Score | Category |
|---|---|---|---|
| 1 | Language | 0.87 | Valid |
| 2 | Sentence | 0.93 | Valid |
| 3 | Learners | 0.90 | Valid |
| V average value | | 0.90 | Valid |

*b) Practicality Test*

Based on the data obtained from the test, it gives an overall average of 4.43, which is a validity level of 88.8%. Thus, the practicality of the media is classified as "very practical". For each sub-variable, an average of 4.42 was obtained for the ease of use variable, 4.5 for the efficiency of learning time, and 4.46 for the suitability variable.

*c) Effectiveness Test*

This effectiveness test begins with a pre-test which is tested on students who have studied solubility material and solubility product without using e-modules. This aims to determine students' understanding/knowledge about solubility material and solubility product. After carrying out the pre-test, then the e-modules that have been developed are presented to students. After that, a post-test was carried out to determine the effect of using the e-module on students' knowledge of the solubility material and the solubility product. Pre-test and post-test results data were analyzed using the t-test. More complete data can be seen in the attachment. The effectiveness test steps using the t-test are as follows:

a) Calculating the difference (d)
   d = post test score – pre test score
b) Calculates the mean difference
   $Md = \frac{\sum d}{N}$
   $= \frac{345}{24}$
   Md = 14.3
c) Calculating using the t formula:
   $t = \frac{Md}{\sqrt{\frac{\sum x2d}{N(N-1)}}}$ $t = \frac{14.3}{\sqrt{2.11}}$
   $t = \frac{14.3}{\sqrt{\frac{1165.76}{24(23)}}}$ $t = \frac{14.3}{1.45}$
   $t = \frac{14.3}{\sqrt{\frac{1165.76}{552}}}$ t = 9.86

Based on the results of the effectiveness test on e-module products, a t-count of 9.86 was obtained. Then look for the t-table value with df = N-1 = 24-1 = 23 with α 0.05, then t-table (9.86 > 2.069). So it can be concluded that there is a significant difference in the results of the pre-test and post-test. Then there is the influence of the e-module on the chemistry subject matter of solubility and solubility product.

*Disseminate*

This stage is carried out to follow up on the product being developed in the form of a process of spreading the product to a wider scope. At this stage the researcher provided a link to the e-module learning media based on the 5E Instructional Model to the vice principal and Chemistry teacher for class XI.

One of the efforts made to present solubility material and solubility product is by making learning media in the form of e-modules. The choice of media is because it can contain learning videos, animations, images, audio, and virtual laboratories to be used at any time. In addition to the selection of learning media, determining the appropriate learning model is also an important thing to understand. The 5E Instructional

Model is a learning model developed based on constructivism theory, in which students construct their own knowledge and are actively involved in every stage of the learning process (Siwawetkul et al., 2020).

1) *Validity of the E-Module Based on the 5E Instructional Model*

On media validity using indicators from (Bozkurt et al., 2015) namely components, content, interface, interactivity, technology. The results of the e-module media expert validator assessment based on Table 2 show that the Aiken's V value for the component aspect is 0.83 in the valid category. This shows that the developed components of the e-module are complete, clear and systematically arranged. The interactivity aspect obtained a value of 1 valid design and its constituent components can create interaction in the learning process. The feasibility of this interactivity aspect according to (Wijaya, 2011).

The next validity test is the material validity test, the assessment aspect consists of four aspects, namely content appropriateness, linguistic components, presentation components and graphic components. The assessment of the feasibility aspect of the e-module content, solubility and the solubility product based on the 5E instructional Aiken's V on the content component, is 0.88 in the valid category. The value of Aiken's V e-module is based on the 5E instructional model. This shows that the content component aspect includes the suitability of the material contained in the e-module with KI, KD, learning objectives to be achieved and the material provided is appropriate to ability (Rochmad, 2012).

The author's use of language in discussing solubility material and solubility products in the e-module is used to evaluate linguistic component features. Based on Table 3, the validator's assessment produces a V Aiken of 0.95 in valid terms, indicating that the solubility and solubility products of the e-module based on 5E learning apply good, straightforward and clear Indonesian language rules so that they are easily understood by e-module users. According to the Ministry of Education and Culture (Kemendikbud, 2017), a good e-module must use clear, easy to understand language and common words to make it user friendly.

The e-module layout is neatly arranged according to the 5E instructional model syntax, and the design and colors used are attractive. The macroscopic representations used have been adapted (Chittleborough et al., 2007) so that observations at the macroscopic level can go through everyday experiences. The submicroscopic representation used in the e-module (Treagust, 2008) already describes macroscopic phenomena at the atomic/molecular level. This is in accordance with the statement (Jansoon et al., 2009).

2) *Practicality of the 5E Instructional Model-Based Chemical Equilibrium E-Module*

This practicality test involving students in the attachment was obtained at 4.43, which has a practicality level, which means that the solubility e-module and solubility product based on 5E instructional are practically used in the learning process. In terms of ease of use, the average results show that the 5E e-module makes it easy (Kemendikbud, 2017). This simplicity of use is related to the clear language of the e-module (Asmiyunda et al., 2018).

3) *Test the Effectiveness of the 5E Instructional Model-Based Chemical Equilibrium E-Module.*

Based on the results of calculations using the t test, it is known that the average pretest score is 62.5. Posttest average value of 76.8. This shows an increase in value. The calculated t value is 9.86 based on efficacy test data with the t test. Then it is known that df = N-1 = 24-1 = 23 and 0.05, look for the t-table value, namely 2.069. As a result, the t-count is greater than the t-table (9.86 > 2.069). As a result, there is quite a large variation in scores between the pretest and posttest results. Thus, the use of e-modules influences student learning outcomes in chemistry subjects, especially solubility and solubility products (Seruni et al., 2020).

## Conclusion

Based on the research conducted, it can be concluded as follows. 1) E-modules based on the 5E instructional model in chemistry class XI have been produced through research and development with a 4-D development model. 2) E-modules based on the 5E instructional model in chemistry subjects that have been developed have a high level of validity, high practicality and high effectiveness on student learning outcomes. 3) The effectiveness of the e-module based on the 5E instructional model in chemistry subjects, especially solubility material and solubility product shows a significance value of 9.86, which means it influences student learning outcomes.

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**Author Contributions**
Contributing authors include Dr. Indrati kusumaningrum, M.Pd as media validator, Dr. Abdurrahman, M.Pd as the language validator, Warnida Aryanti, S.Pd as the material validator. Prof. Dr. Z. Mawardi effendi, M.Pd as supervisor. old man and friends.

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**Conflicts of Interest**
The authors declare no conflict of interest.

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