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Validation of Discovery Learning E-Module based on Video Demonstration on Chemical Equilibrium for High School Student

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Abstract: This study aims to determine the validity of discovery learning-based E-modules integrated with video demonstrations on chemical equilibrium material for high school students. The type of research conducted was research and development (R & D) with the Plomp development model. This study involved six chemistry lecturers at the Faculty of Mathematics and Natural Sciences and the Faculty of Engineering, Padang State University, two high school chemistry teachers from SMAN 7 Padang and MAN 3 Payakumbuh, and involved XI grade students in each school. The data collection technique used was a questionnaire. The research data was processed using Aiken's V formula. Based on the research results, the e-module was in the "valid" category with a value of 0.86.

Keywords: E-module; Chemical equilibrium; Discovery learning; Video demonstration; Validity.

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Introduction

The world of education is constantly adapting to technological developments to improve quality, mainly by adjusting the use of information and communication technology in the learning process (Budiman, 2017) (Malik, 2018). The learning process aims to teach students to think critically about a concept and relate it to real-life examples so that they can understand it better (Ellizar et al., 2019) (Kurniawati, 2019). It adheres to the 2013 revised 2017 curriculum, which states that learning should involve students forming concepts from material rather than simply transferring material from teacher to student (Permendikbud, 2013).

Chemical equilibrium is a material that requires a thorough understanding and will be easier for students to understand by guiding them through acquiring knowledge, and students must find the concepts (Yerimadesi et al, 2016; Lopera et al., 2014). The appropriate learning model is the discovery learning model, where students can find their way through problem-solving approach techniques (Supardi, 2013; Nurcahyo et al., 2018; Rizki et al., 2021).

The findings obtained from observations at schools were that there was no practicum implementation at MAN 3 Payakumbuh and only 23.1 percent of practicum implementation at SMAN 7 Padang. Based on interviews with teachers, the COVID-19 pandemic and the lack of facilities and infrastructure are still the reason. The COVID-19 pandemic requires avoiding physical contact, so this provision requires schools to apply various rules, including the odd-even system or shift, as well as online learning (Almaiah, 2020).

Several points were obtained based on the questionnaire analysis of the chemical equilibrium material distributed, including 69.4 percent of students stating that the chemical equilibrium material was challenging to understand. Current teaching materials

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were deemed unappealing by 88.5 percent of those polled. Students have learning difficulties because of the lack of facilities and infrastructure in schools; the atmosphere of COVID-19, which still limits the steps for conducting experiments; and learning becomes more complicated when there is much material to cover in a short amount of time. The problem is that not all students can digest material information quickly.

One solution to this problem is to replace the learning media (Indina and Maryanti, 2021; Dewi and Harini, 2021). An e-module is a type of teaching media made digitally or without print so that students can learn independently (Fausih, 2015; Priantini and Widiastuti, 2021). The developed e-module will be integrated with the demonstration video. This demonstration video is intended to help with practical activities that cannot be done (Brame, 2016; Masril et al., 2018; Afrrannisah et al., 2021).

Students can access this e-module easily because, based on observations and questions, information obtained indicates that school facilities and infrastructure were adequate, such as the availability of computers in schools and students' laptop computers. The data shows that every student has a cell phone, and this e-module can be accessed through the student's phone. Furthermore, teachers and students are enthusiastic about using e-modules, as evidenced by the 100 percent interest in learning chemistry through e-modules.

Based on the description above, the researcher conducted research entitled "Development of Discovery-Based Learning E-Module with Video Demonstration of Chemical Equilibrium and Chemical Equilibrium Materials."

Method

The type of research conducted was Educational Design Research (EDR) (Tessmer, 1997). This type of research is a research method used to develop or validate products used in education and learning (Tessmer, 1997; Sugiyono, 2011). The research and development aim to create and deliver teaching material in an e-module equipped with a good demonstration video, and chemical equilibrium material was chosen as the topic. The places for the research were SMAN 7 Padang and MAN 3 Payakumbuh, and the time of its implementation was 2021. The subjects of this research were two chemistry teachers from MAN 3 Payakumbuh and SMAN 7 Padang, and students from classes XI IPA 1, MAN 3 Payakumbuh, and SMAN 7 Fields.

The E-Module Chemical Equilibrium research procedure was designed using the plump model. The development of this plump research model consists of 3 stages: (1) preliminary research (initial investigation phase), (2) prototyping phase (design phase), and (3) assessment phase, but in this study, it will only be limited to phase 2 (Plomp, 2010). The description of the activities at each stage of the development was as follows:

Preliminary Research

1) Needs and Context Analysis

A needs analysis activity was carried out by distributing questionnaires to identify problems regarding chemical equilibrium materials at MAN 3 Payakumbuh and SMAN 7 Padang.

2) Curriculum analysis

The chemical syllabus was analyzed at this stage, especially the chemical equilibrium material, which determines a critical discussion about the factors affecting the chemical equilibrium shift.

3) Literature Review

From the problems found based on the distribution of the questionnaire, analysis was carried out by reviewing some of the literature and studies relevant to research activities.

4) Conceptual Framework Development

The conceptual framework stage was developed after getting problems from the needs analysis and literature study. At this stage, identification, details, and the main points learned were carried out.

Prototyping phase

The product design stage was where the e-module was designed. A formative evaluation was carried out for each prototype produced at this stage. A formative assessment was classified into several steps. At the prototype stage, several activities were carried out, which are described as follows:

1) Prototype 1

The stage of designing the e-module was governed by the steps of the discovery learning model. Several applications were used to create the E-Modules. The cover design was made using the Canva application, while the contents of the e-module were created using the Microsoft Word application. Designing the items to be included in the e-module according to the learning objectives. These items were videos, images, and animations related to the material. A practicum video was recorded and edited using a flip marker application and was made as attractive as possible. The footage was inserted using the Flip PDF cooperation application. Make questions about each syntax that will lead students to concepts. Making evaluation questions as an exercise for students to test their understanding. The finished e-module was converted using the Flip PDF cooperation application and uploaded online, accessed via a link.

2) Prototype 2

This stage carried out a formative evaluation of the e-module created. This evaluation was carried out with a checklist system on essential parts contained in the e-module. If things were not perfect, further improvements would be made to the e-module to produce prototype 2.

3) Prototype 3

A formative evaluation at this stage, a one-to-one review, and an expert review was to obtain the level of validity and practicality of the developed e-module. (1) Expert review: The expert review evaluation and evaluation were carried out by lecturers at FMIPA UNP, using an instrument in the form of a questionnaire. The evaluation results were then analyzed to determine the validity value of the created e-module; (2) One-to-one Evaluation: Three students carried out one-to-one trials. These students were shown an e-module based on discovery learning design and then filled out the interview sheet given. Then, revisions were made based on the validator's suggestions, and the interview sheets were analyzed on a one-on-one trial to produce a valid e-module.

Data Analysis Techniques

The research instrument was arranged to be used in assessing the resulting e-module. The research instrument used was in the form of a questionnaire. The questionnaire is a set of questions or written statements that respondents will answer to obtain data from these respondents (Sugiyono, 2016). Based on the research objectives conducted by the researcher, the instrument was designed and arranged, which was the validation instrument.

This instrument was in the form of a validation sheet to develop an integrated discovery-based learning chemical equilibrium e-module given to the validator. This validation sheet was used to assess the feasibility of the content or content of the resulting e-module. The results of the questionnaire analysis were used to determine the level of validity of the e-module.

The analysis technique of learning media validation was carried out to see whether the data from the verification of the learning media that had been developed was feasible to proceed to the next stage or not. The formula used for validation was Aiken's V index (Lewis, 1985).

Result And Discussion

This research produces a discovery-based learning chemical equilibrium e-module equipped with a virtual laboratory. This study uses the Plomp development model, which consists of three stages, with the results described as follows.

Preliminary Research

1) Needs and Context Analysis

The needs analysis activity was carried out by distributing questionnaires to identify problems regarding chemical equilibrium material in XI grade. From the questionnaire results, it can be concluded that: 1. A total of 69.4% of students answered that the material for chemical equilibrium was challenging to understand; 2. A total of 88.5% stated that the teaching materials were less attractive; 3. There is a lack of facilities and infrastructure at schools; 4. The atmosphere of Covid 19 still limits the steps for conducting experiments; 5. Much material but less or shorter learning time makes learning ineffective.

2) Curriculum analysis

The chemical syllabus was analyzed at this stage, especially the chemical equilibrium material, which led to a critical discussion about the factors affecting the chemical equilibrium shift. Curriculum analysis was carried out at KD 3.8, 3.9, and 4.8.

3) Literature Review

From the problems found based on the distribution of the questionnaire, analysis was carried out by reviewing some of the literature and studies relevant to research activities. Some of the articles used as supporting articles in this research were Zulkarnain et al, (2015), which show the validity, implementation, and feasibility of the effectiveness of the e-module on the developed atomic theory material. Another research also used was Febriayana & Sakti (2017) research about student learning outcomes that increase when using e-modules.

4) Conceptual Framework Development

After getting problems from the needs analysis and literature study, the conceptual framework was developed. At this stage, identification, details, and the main points learned were carried out.

Prototyping phase

This stage was the product design stage. A formative evaluation was carried out for each prototype produced at this stage. A formative assessment was classified into several steps. At the prototype stage, several activities were carried out, which were described as follows:

1) Prototype 1

a) Cover E-Module

The cover section of the e-module contains the module's identity, including the title of the e-module, the name of the author, the author's agency, the target of the e-module, supporting images, and the author's supervisor. The title of the e-module was to provide information about the material being discussed. The

author's name and agency provide information to users about the author of the e-module and the author's agency. The target of the e-module was to provide information about the users of the e-module. The e-module cover was designed with a dominant orange color. The use of color in the e-module cover design stems from the distributed questionnaire to make students interested in learning. The display of the e-module cover can be seen in Figure 2.

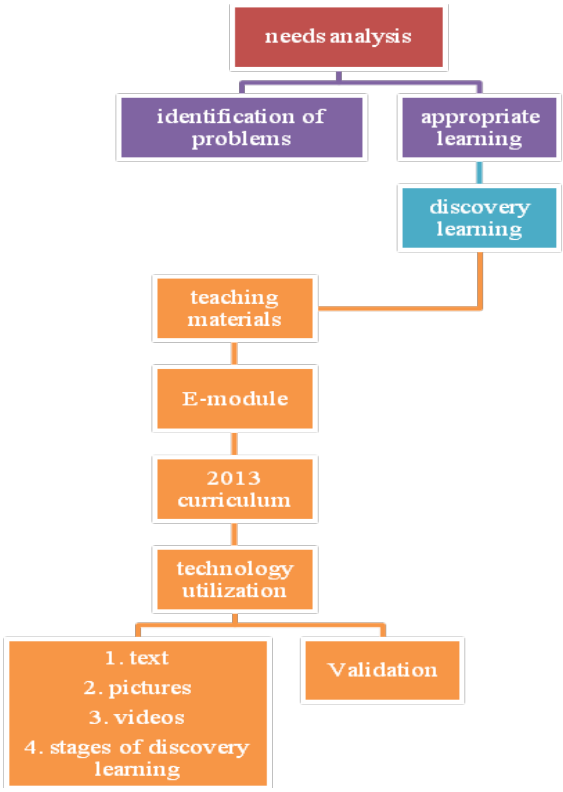

Figure 1. The resulting conceptual framework

b) Instructions for the use in E-Modules

Instructions for learning in the e-module consist of instructions for teachers and students using discovery learning syntax.

c) Competencies to be achieved

The presentation of KD, GPA, and learning objectives aims to make teachers and students aware of the competencies that must be achieved in the learning process.

d) Activity Sheet

The activity sheet in the e-module uses the discovery learning stage. The stages of this learning model were: (1) Stimulation: Students will be given a problem in everyday life, making them think about why a phenomenon can happen; (2) Problem Statement: At this stage, students will be allowed to identify problems relevant to the subject matter as much as possible and then choose one, which will be used as their hypothesis; (3) Data Collecting: The data collection stage is the stage for students to explore and collect information; (4) Data Processing: The data processing stage allows students to answer questions, provide simple explanations, find concepts from the material being studied, and offer reasons for answering questions; (5) Verification: Students examine carefully to prove whether or not the hypothesis is determined by the findings and is linked to the results of the processed data; (6) Generalisation: At this stage, students will draw conclusions obtained from previous processes, which can be used as a concept.

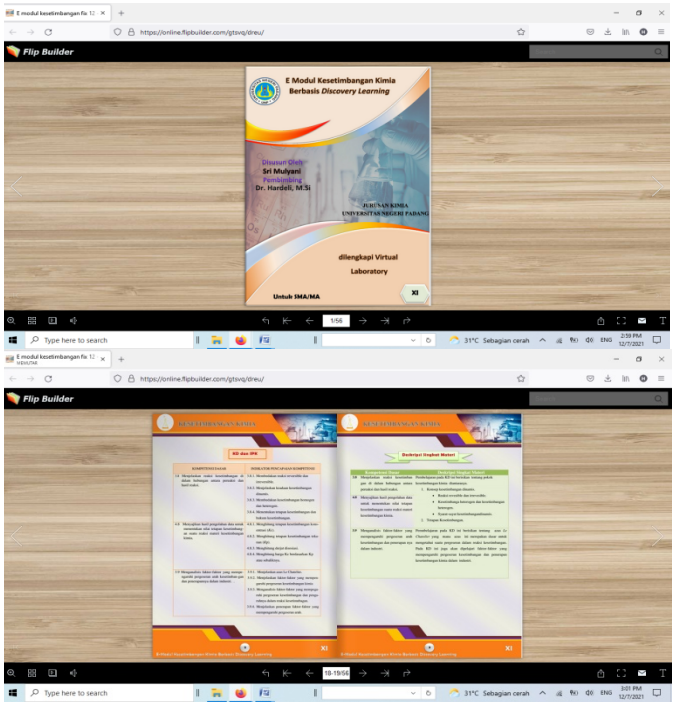

Figure 2. (a) E-Module cover (b) KD, GPA, and a brief description of the material

e) Evaluation

This section contains multiple-choice questions that summarise all the learning objectives. The evaluation sheet consists of 20 questions with five options: a, b, c, d, and e. their answer will be connected to the Google form.

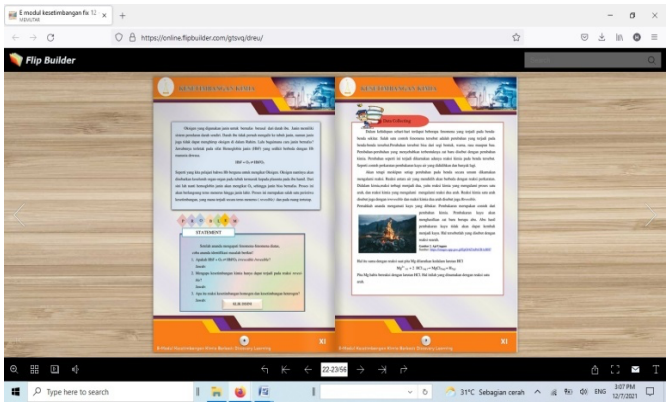

Figure 3. Example of an E-Module Activity Sheet

f) Videos

In the e-module, there are videos, both practical demonstration videos and animated videos.

g) Virtual Laboratory

In the e-module, a virtual laboratory will also be presented that student can use to conduct simple experiments.

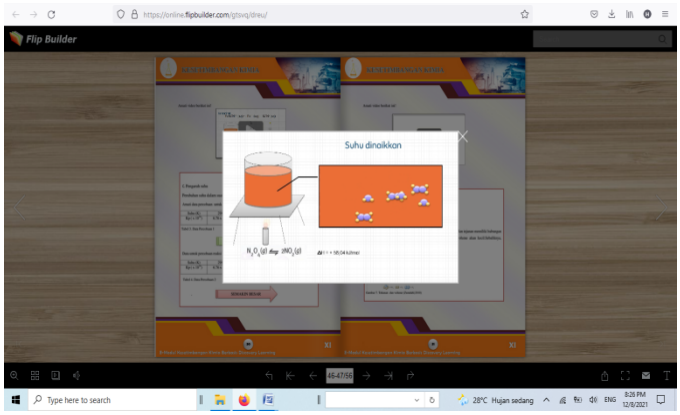

Figure 4 Examples of videos in the e-module

h) Answer key

This section contains answers to the questions in the worksheets and evaluation sheets. Students can match the answers obtained with the available answer keys, and then students can measure their level of ability after studying all the material in the learning process.

i) Bibliography

This section contains reference sources used in compiling the discovery learning-based chemical equilibrium e-modules.

2) Prototype II

The resulting prototype was evaluated using a self-evaluation test. The evaluation results stated that the prototype I made was complete with the proper e-module based on the Kementerian Pendidikan dan Kebudayaan (2017). It includes cover, table of contents, glossary, competencies (KD and GPA), instructions for use, activity sheets, exercises, assessments, self-evaluation, answer key, and bibliography.

3) Prototype III

At this stage, a formative evaluation was carried out in the form of an expert review and a one-to-one assessment to obtain the level of validity of the developed e-module.

a) Expert Review

Three expert validators validated the resulting prototype II. The validity tests consisted of content, construct, language, and graphical components. The validity data collection instrument used was in the form of a validity questionnaire.

• *Content Components*

The content validity questionnaire of the chemical equilibrium e-module based on discovery learning contains two aspects of assessment: the suitability of the e-module with discovery learning syntax and the element of the correctness of the content e-module in the range of chemistry. The results of evaluating the validity of the chemical equilibrium e-module based on discovery learning on the content components can be seen in table 1.

• *Construct Components*

The results of the construct validity of the discovery learning-based chemical equilibrium module developed can be seen in the table 2.

• *Language Component*

The results of evaluating the validity of the chemical equilibrium e-module based on discovery learning on the linguistic component can be seen in the table 3.

• *Graphical Component*

The results of evaluating the validity of the chemical equilibrium e-module based on discovery learning on the linguistic component can be seen in the table 4.

Table 1. Results of Content Components

Rated aspect	V	Validity
Basic Competence (KD) 3.8, 3.9, and 4.8 were used to develop competency achievement indicators.	0.83	Valid
E-Module builds according to KD 3.8, KD 3.9, and KD 4.8.	0.91	Valid
Formulation of Learning Objectives according to Competency Achievement Indicators.	0.83	Valid
The material presented in the E-Module is by the Competency Achievement Indicators.	0.91	Valid
The pictures and videos used in the E-Module are from the chemical equilibrium material.	0.91	Valid
The images and videos used in the E-Modul are scientifically correct.	0.83	Valid
The stimulation provided can direct students to find concepts.	0.91	Valid
The questions given in data processing, exercises, and evaluations are related to the chemical equilibrium material being studied.	0.91	Valid
The contents of the E-Module can add insight to students' knowledge of chemical equilibrium.	0.83	Valid
The contents of the E Module are by the level of students.	0.91	Valid
Average	0.88	Valid

Table 2. Results of construct components

Rated aspect	V	Validity
The e-Module is made according to learning indicators for chemical equilibrium material.	0.83	Valid
The e-Module was made according to the learning objectives for the chemical equilibrium material.	0.91	Valid
The questions presented have directed students to achieve indicators of competency achievement	0.83	Valid
The questions presented already meet the range of cognitive levels in C2-C4.	0.83	Valid
The questions presented in the E-Module can direct students to think critically.	0.91	Valid
The contents of the E-Module are systematic, starting from the title, core competencies, essential competencies, achievement indicators, learning objectives for learning activities, exercises, and evaluations.	0.83	Valid
The presentation of the E-Module is based on discovery learning steps, namely: a) stimulation, b) problem statement, c) data collection, d) data processing, e) verification, f) generalization.	0.91	Valid
Average	0.86	Valid

Table 3. Results of Language Components

Rated aspect	V	Validity
The readability of the E-writing, Module's images, and videos.	0.86	Valid
The language used in the E-Modul is already communicative.	0.83	Valid
The language used in the E-Module is unambiguous and has a double meaning.	0.91	Valid
According to the Indonesian spelling, the language used in the E-Module is excellent and correct.	0.83	Valid
Consistent in using symbols/symbols contained in the E-Module.	0.91	Valid
The language use is effective and efficient (clear and concise).	0.83	Valid
Average	0.86	Valid

Table 4. Results of Graphical Components

Rated aspect	V	Validity
The typeface used is legible.	0.83	Valid
The font size used is legible.	0.91	Valid
The layout or display of the cover and between the inside of the E-Modul is attractive.	0.83	Valid
The images presented can be observed clearly.	0.91	Valid
The animation presented can be observed clearly.	0.83	Valid
The video presented can be seen clearly.	0.83	Valid
The overall design of the discovery learning-based chemical equilibrium E-Module is attractive.	0.83	Valid
The duration of the video already meets the learning standards.	0.83	Valid
Virtual Laboratory presented can be operated, and the duration meets the standard.	0.83	Valid
Average	0.85	Valid

Table 5. The results of the data processing of the construct validity assessment can briefly be seen in the table.

Rated aspect	V	Aiken
Content Component	0.88	Valid
Construct Component	0.86	Valid
Language Component	0.86	Valid
Graphical Component	0.85	Valid
Average	0.86	Valid

Table 6. Improvement suggestions from reviewers

No	Improvement suggestions from reviewers
1	Improvements to bidirectional reaction arrows. In the e-module before validation the two-way reaction arrow was like this, it was not written correctly so it was corrected again to one that has a two-way reaction direction
2	Improved writing in the table of contents by adding a title for each topic. Writing the table of contents before the validation is done only writes worksheet I, worksheet II, and worksheet III only. After the revision, each worksheet was replaced with the titles of each topic. Topic I was replaced with Dynamic Chemical Equilibrium, worksheet II was replaced with Equilibrium Constants and worksheet III was replaced with Factors Affecting Equilibrium Shifts.
3	Include sources in the video. In the e-module before the revision of each video taken from YouTube to increase students' understanding, it is not accompanied by a link to the source of the video. After validation, each video taken from YouTube includes the source link.
4	Equalize or be consistent with the use of symbols and buttons. This is so that each syntax or stage has uniformity which makes the e-module better to look at and its use does not confuse students. For example, before box validation and also the use of symbols and buttons have differences, but after revision they have similarities.

No	Improvement suggestions from reviewers
5	Changed the picture on the first K.D 3.8 GPA stimulus. Before validation, the image on the first GPA was considered to be less representative of the actual situation. The image referred to is a picture of a baby in a fetus, the first image is a non-scientific illustration.
6	Fixed uniformity with buttons on items on e–module buttons. The uniformity of these buttons is useful to make it easier for students to work on and use the e-module.
7	Adding the e-module manual to the e-module. The e-module manual is useful as a guide for students and teachers in using the e-module.
8	Changing the e-module background. The background on the e-module before the revision is plain and flat in color, so that the validator's suggestion will make students bored so that the background of the e-module is replaced.
9	Adding a draft to the e-module. The addition of the draft e module is useful as a quick step or shortcut for linking one page to another.
10	Add learning objectives to each topic to be discussed. This addition aims to make each topic title visible learning objectives or learning objectives. The learning objectives made are point-by-point learning objectives so that students can measure and assess themselves.
11	Tidy up the arrangement of each video and the existing buttons. This is useful for making students comfortable in learning and using the e-module so that students are more interested in learning to use the developed e-module. In addition, replacing the use of English with Indonesian, this is because the use of foreign languages is feared to make students lazy to understand.

Following the revision of the E-module, the validator validates the next stage. This revision aims to improve the e-module based on the validator's suggestions. The validator's suggestions and inputs were used as guidelines in revising the discovery learning-based chemical equilibrium e-module created.

b) One-to-one evaluation

The one-to-one evaluation test was carried out by distributing questionnaires to three students with different abilities: high, medium, and low. The teacher who teaches them in school divides the students based on her observation, taking into account various aspects. Based on the analysis results, it was determined that the prototype II produced was attractive in terms of cover appearance and color selection, which was considered excellent and able to attract students' interest in learning it. The choice and use of the font in the e-module were pretty straightforward, and the language used was easy to understand. The material presented in the e-module was excellent and easy to understand. Instructions for using e-modules contain several details that make it easier for students to learn from e-modules. The pictures, tables, and videos presented in the e-module were considered capable of helping students understand the learning material.

The research aims to develop a discovery learning-based chemical equilibrium e-module for XI grade in high school. In this study, the quality of the developed product was limited to the validity of the developed e-module. The study obtained a chemical equilibrium e-module containing the discovery learning syntax. Product development was carried out through two stages using the Plomp development model: preliminary research and prototyping.

The purpose of conducting preliminary research was to determine the main problems in schools and find solutions to these problems (Almaiah, 2021). According to the 2013 revised 2017 curriculum, students must be active in learning, especially finding concepts (Indonesia Ministry of National Education, 2017). The implementation of this idea can be carried out using a discovery learning model. This learning model is believed will help students find concepts.

The discovery of concepts will make students think critically (Wahida, 2021). One way to make students active and think critically is through the direct learning experience, which can be done by implementing a practicum. Unfortunately, the learning process was currently experiencing some obstacles. The COVID-19 pandemic and the non-availability of facilities and infrastructure hinder this implementation. The solution could be developing learning media in teaching materials, e-modules, to help students learn. The e-module will be equipped with pictures, videos, exercises, and evaluations on the e-module that will facilitate learning.

Each prototype produced during the prototyping stage was subjected to a formative evaluation. The purpose of formative assessment was to improve the quality of the resulting product. The resulting product was developed to prepare e-modules from the Indonesia Ministry of National Education, (2017). Lesson objectives (KD and GPA), material descriptions (summaries), assignments (objectives, material descriptions, summaries), exercises, self-assessment, evaluation, answer keys and scoring guidelines, and bibliography comprise the e-module (Indonesia Ministry of National Education, 2017).

From prototype I to prototype 3, a formative evaluation was carried out to improve the quality of the resulting product. The evaluation technique used consisted of self-evaluation (self-evaluation), one-to-one evaluation (one-on-one trial), expert review (expert assessment), and small group (small group trial) (Plomp, 2010). The evaluation determined the quality of the

resulting product in the form of a discovery learning-based chemical equilibrium e-module for class XI SMA/MA.

The assessment of the validity of the chemical equilibrium e-module based on discovery learning was carried out by two chemistry lecturers from the Faculty of Mathematics and Natural Sciences (FMIPA) of Padang State University (UNP), three lecturers in informatics engineering from the Faculty of Engineering (FT) of Padang State University (UNP), and four chemistry teachers. The results of the validity of the chemical equilibrium e-module based on discovery learning were obtained from the research instrument in the form of a validity questionnaire. There are three validity tests: the content validity test, the construct validity test, and the media validity test. The content validity assessment consists of two components: the suitability of the e-module content with discovery learning syntax and the correctness of the e-module content with scientific chemical content. The construct validity assessment consists of four components: content, construct, linguistic, and graphic details. Display aspects, programming aspects, and utilization aspects are all assessed for media validity.

The assessment given by the validator was analyzed using the Aiken's V formula to determine the level of validity of the developed e-module. The determination of the validity decision category of Aiken's V can be seen in Table 5. The assessment aspect for construct validity consists of a content component, a linguistic component, a presentation component, and a graphic component (Indonesia Ministry of National Education, 2008).

The component aspects of the chemical equilibrium e-module content based on discovery learning were related to the developed e-module. The validation results in Table 1 show that the average value of Aiken's V is 0.88 with a "valid" category, indicating that the discovery learning-based chemical equilibrium e-module that was developed is based on KD 3.8, KD 4.8, and KD 3.9 of the 2017 revised 2013 curriculum. The content component aspects include the suitability of the material in the e-module with KI, KD, and learning objectives and whether the material provided is appropriate for students' abilities.

Based on table 2, the assessment of the aspects of the construct component of the chemical equilibrium e-module based on discovery learning, the average value of Aiken's V is 0.86 with a "valid" category. It shows that the discovery learning-based chemical equilibrium e-module presentation developed has been systematically arranged based on the e-module components by the e-module compilation guidelines from the Indonesia Ministry of National Education (2017).

The assessment of aspects of the linguistic component is related to the author's language in explaining the chemical equilibrium subject in the e-module (Yosa, et all., 2019). Based on table 3, the assessment results by the validator obtained, the average value of Aiken's V is 0.86 with a "valid" category. It shows that the discovery learning-based chemical equilibrium e-module that was developed uses sound, simple, and clear Indonesian so that e-module users can easily understand it. According to Indonesia Ministry of National Education, (2017), this is the case. The language used in e-modules was communicative, interactive, and semi-formal, allowing students to understand it easily.

The assessment of the visual component aspects of the chemical equilibrium e-module based on discovery learning was related to the appearance or design of the e-module as a whole, such as a layout, logo, and symbol presented (Bennett, 2019). The proportions must be appropriate and attractive. The results of the validator's assessment for the graphic component based on Table 4 obtained the average value of Aiken's V of 0.85 with a "valid" category. It shows that the appearance or design of the e-module has been presented attractively. The existence of an attractively designed e-module will increase the motivation of students to read learning materials (Asmiyunda, et all., 2018).

Based on the table, it was obtained that the average Aiken's V for all aspects of the e-module construct validity was 0.86. Thus, the construct validity of the discovery learning-based chemical equilibrium e-module developed was included in the "valid" category.

Conclusion

The E-Module of chemical equilibrium based on discovery learning for class XI SMA/MA can be developed using the Plomp development model. The developed E-Module was valid, with a value of 0.86.

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