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The effectiveness of e-modules based on discovery learning model integrated by probing-prompting questions in high school chemistry learning

Hardeli*, Mesi LisdaYenti, Haifa Hafifah, EkaYusmaita, Yerimadesi

Chemistry Education, Chemistry Department, Faculty of Mathematics and Natural Science, UniversitasNegeri Padang, Padang 25132, Indonesia

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Abstract

Fundamental laws of chemistry and voltaic cells e-modules that are valid and practical based on discovery learning integrated by probing prompting question has been developed. This research aims to analyze the effectiveness of e-modules based on discovery learning integrated by probing prompting questions on fundamental chemical laws and voltaic cell matter for high school learning. The type of research was pre-experimental with one group pretest-posttest design. The population and sample of this research were grade XII of HiliranGumanti high school and grade X Pratiwi high school. The sampling technique used purposive sampling technique. The research instrument was a test with 25 multiple choice questions. The result of analysis on effectiveness data showed an average N-gain value of 0.68 categorized as moderate on fundamental chemical laws matter, and 0.51 as moderate category in voltaic cell matter. The hypothesis test using the paired *t*-test sample obtained *t*-count > *t*-table, namely, 7.96 > 1.69 on basic chemical law material and 6.8 > 2.0 on voltaic cell material showing that the learning outcomes of students were enhanced after being given treatment of e-modules implementation. Therefore, e-modules based on discovery learning integrated by probing prompting questions on chemistry learning matters are effective in improving student outcomes.

Introduction

Chemistry is a branch of science that studies the structure, composition, properties, and changes in matter and the energy that accompanies these changes in matter. One of the chemistry subjects studied in school is the fundamental laws of chemistry and voltaic cells. Fundamental laws of chemistry is studied in grade X high school and voltaic cells is studied in grade XII high school. These two matters have in common that they contain abstract concepts. The fundamental chemical laws material is the basic concept for studying the next matter, namely, the development of the concept of moles and stoichiometry. Therefore, students are expected to understand the fundamental laws of chemistry in advance so they will not see difficulties while understanding the

* Corresponding author.
E-mail address: hardeli22@fmipa.unp.ac.id, hardeli123kimia@gmail.com (Hardeli).

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next matter. Fundamental chemical laws matter consists of five laws, namely, the law of conservation of mass (Lavoisier's law), the law of definite proportions (Proust's law), the law of multiple proportions (Dalton's law), the law of volume ratio (Gay-Lussac's law) and Avogadro's hypothesis (Avogadro's law). According to Mardani (2020), the fundamental laws of chemistry contain abstract concepts that students often find difficult. This is in line with what was found in reality, where at Pertiwi High School, 70.8 percent of students stated that fundamental chemical law material was in the difficult category. The students also stated that such made it hard to compare and remember each law.

Voltaic cell matter discusses chemical reactions that can produce electrical energy. This matter discusses how the voltaic cell occurs, whether the redox reactions involved occur spontaneously or not, the potential value of the cell that is formed, and explains the use of the voltaic cell in life. According to the results of observations of two school in Hiliran Gumanti, the teaching materials used for Voltaic cells were less interesting. 65 percent of students stated that the voltaic cell material was difficult to understand. The results of the interviews submitted to the school chemistry teacher stated that student learning outcomes in the voltaic cell material were quite low because students did not restudy the lessons outside of class, so it was difficult to remember. Another contributing factor is that teachers still use the lecture method where information is teacher-centered learning, so students are less active in discovering concepts during the learning process. In response to this, teaching materials are needed that can help students find concepts and can increase student activity in learning using e-modules.

Literature Overview

E-module is one of the teaching materials that contains the presentation of material that is arranged systematically and can display audio-visual, video, animation, and interesting illustrations to attract students' interest in learning (Deddy, 2010). Teaching materials in the form of e-modules are considered effective for guiding students to be active during the learning process (Herawati, 2018). The e-module contains the stages of the discovery learning model and is equipped with a series of probing prompting questions. Learning with the probing prompting questions aims to increase student activity in the questions given through the e-module so that it can train thinking skills and help students find concepts (Muthmainnah et al., 2019).

The probing prompting question is integrated learning by asking a series of questions by the teacher that are guiding so that a thought process occurs that connects students' knowledge and experience with newly learned knowledge (Shoimin, 2014). The probing prompting question can make students more focused. The discovery learning model is considered suitable for integrating prompting probing questions, where each learning step can be combined with guiding questions (Huda, 2013).

E-modules are arranged based on the stages of the discovery learning model. This discovery learning model is one of the implementations of the 2013 curriculum. Learning in the 2013 curriculum requires students to be able to learn actively during the learning process, where the teacher is only a facilitator or motivator and learning resources can be linked to aspects of everyday life (Laili, 2019). The discovery learning model is a student-centered discovery learning model so that students can form an understanding of critical thinking (Ellizar et al., 2019). During the learning process using the discovery learning model, students are expected to play an active role in finding concepts through the help of learning resources provided by the teacher (Asda, 2021).

According to the results, information is obtained that the use of teaching materials in the form of e-modules is effective in improving student learning outcomes (Hasibun, 2021). Other research mentions that the use of e-module teaching materials can help find concepts rather than using teaching materials other than e-modules (Agung, 2020). Based on the background of the problems that have been described, this study aims to test the effectiveness of e-modules based on discovery learning integrated by probing prompting questions on chemistry leaning with the study case of fundamental chemical laws and voltaic cell matter.

Methodology

This type of research was a pre-experiment with a One Group Pretest-Posttest design. According to Sugiyono (2013), pre-experimental research can be interpreted as experimental research that is not yet real because there are external variables that influence it. One of the external variables which can influence this research result is students' activity outside of the class. Therefore, the sampling technique is purposive sampling for the students did not have any extra course out of the class to make this research obtaining data accurate and original.

Participants

The population of this research were students of Pertiwi Senior High School with 30 students of grade X, and students from Hiliran Gumanti Senior High School with 20 students of grade XII as the sample.

Data Collection

The One Group Pretest-Posttest design used one class test which begins with giving a pre-test to determine students' initial abilities in the matter on fundamental laws of chemistry and voltaic cells. The pre-test results showed that the classes are processed to get the average score achieved by students. In the next stage, the researcher carried out the process of learning the fundamental laws of chemistry and voltaic cells using the implementation of the e-module that had been developed. Students used the e-module as learning material when answering probing-prompting questions in the e-module. The implementation of this e-module is carried out in 2 meetings with 4 lesson hours × 45 minutes per matter. After learning is complete, students are given a final evaluation (posttest), then the results of the final evaluation are compared to find out the differences in learning outcomes before giving the e-module and after using the e-module from the results of the students' pretest and posttest scores. Students use the e-module as learning material when answering questions in the e-module. The One group pretest-posttest design which was used can be seen in Table 1.

Table 1 One group pretest-posttest research design

Pretest	treatment	Posttest
O_1	X	O_2

Description:

O_1 = test before using the e-learning module

X = learning using e-modules based on discovery learning integrated probing-prompting questions on fundamental chemical laws and voltaic cells

O_2 = test after learning using e-modules.

The data collection technique used in this study was carried out by giving test questions to students. The types of questions given are in the form of multiple choice questions, which consist of 25 fundamental chemical laws questions and 25 voltaic cell questions.

Data Analysis

Analysis of the effectiveness of e-module based on discovery learning is as follows:

1. Normality test

The normality test uses the Lilliefors method because it can be used on data that has large or small *n* (number of samples). The significance of the test is the absolute value of the normal cumulative probability minus the largest empirical cumulative probability compared to the Lilliefors table value with the following criteria:

1) If $|F(x) - S(x)|$ is the largest value in the Lilliefors table, then Ho is accepted: Ha is rejected <

2) If $|F(x) - S(x)|$ is the largest value in the Lilliefors table, then Ho is rejected: Ha is accepted >

3) With Ho: normally distributed data and Ha: abnormally distributed data.

2. Hypothesis test

To test the hypothesis in this study, paired sample t-test was used. The formulation of the research hypothesis is as follows.

H_0 : There is no difference in learning outcomes before and after the use of e-modules based on discovery learning integrated probing-prompting questions.

H_1 : There are differences in learning outcomes before and after the use of e-modules based on discovery learning integrated probing-prompting questions.

The formula (Equation (1)) used is:

$$\frac{\bar{X}-\bar{Y}}{\sqrt{\frac{Sx^2}{n_1}\frac{Sy^2}{n_2}}} \quad (1)$$

3. N-gain test

The N-gain test was carried out to determine the effectiveness of using discovery learning based e-modules integrated with probing prompting questions on student learning outcomes. The N-gain test can be calculated using the formula (Equation (2)):

$$\text{N'Gain} = \frac{\text{Skor Posttest-Skor Pretest}}{\text{Skor Ideal-Skor Pretest}} \quad (2)$$

The category of interpretation of the effectiveness of N-Gain can be seen in Table 2.

Table 2 N-gain Category

N-gain Score	Category
$g < 0,7$	High category
$0,3 \leq g \leq 0,7$	Moderate category
$g < 0,3$	Low category

Source: Hake (1999)

Results

The results of the study show the effectiveness of test data from e-modules that were previously valid and practical, namely, e-modules based on discovery learning with probing prompting questions on fundamental chemical law matter for grade X high school and voltaic cell matter for grade XII high school by Haifa and Hardeli (2022); Mesi and Hardeli (2022).The e-module consists of covers, instructions, basic competencies, competency achievement indicators, materials, and evaluations. The main material on the

basic laws of chemistry is the law of conservation of mass (Lavoisier's law), the law of constant proportions (Proust's law), the law of multiple proportions (Dalton's law), the law of volume comparison (Gay-Lussac's law) and Avogadro's hypothesis (Avogadro's law). The voltaic cell is the process of the occurrence of the voltaic cell, cell notation, cell potential, and the application of the voltaic cell in life. Probing-prompting questions are integrated into each material which is divided into several activity sheets. This activity sheet has several question worksheets that students must fill out in several discovery learning syntaxes, namely, the syntax of problem identification, data collection, data processing, and generalization syntax. Evaluation activities are carried out when students have done worksheets on the e-module to find out students understanding of the basic laws of chemistry and voltaic cell material. However, in this study, students are only given a pretest before learning using the e-module, then given treatment using the e-module to study fundamental chemical laws in grade X and voltaic cells in grade XII. After the learning material is finished with four hours of lessons on each material, students are given posttest questions that are the same as pretest questions to show the impact of students' understanding of the use of e-modules. Pretest and posttest data must be normally distributed to run the normality test.

Normality Test

The Lilliefors test is used on unprocessed fundamental data in frequency distribution tables, ratios, or interval scale data and can be used on high school and high school samples. The samples in this study were 30 students of class X on basic chemical laws and 20 students of class XII on voltaic cells. Table 3 shows the results of the normality test results

Table 3 shows that the calculated L value of the students' pretest and posttest results is greater than the L table value, so Ho is accepted and Ha is rejected. This means the data are normally distributed. Therefore, this data can be used for further statistical tests.

Hypothesis Test

Testing the hypothesis in this study using paired sample t-test. This test is one of the test methods used to assess the effectiveness of the treatment given, which is characterized by the difference in the average before and after being given treatment. The description of the ability to understand the concept of basic chemical law material and voltaic cell material based on the results of the students' pretest and posttest can be seen in Table 3.

Table 4 shows that students' ability to understand basic chemical law concepts and voltaic cell material increased after being given treatment. The results of the t-test show *t*-count is greater than *t*-table. Therefore, it can be concluded that there is a difference in the average pretest and posttest scores.

Based on these results, the average post-test score is higher than the average pretest score. It explains that the developed e-module can increase students' understanding in understanding chemistry lessons. The discovery learning model that actively involves students to discover chemical concepts has a good effect on learning outcomes. In addition, the probing-prompting questions posed in the e-module make students more precise in discovering chemical concepts with the possibility that high school students experience misconceptions when not using this asking technique. Putri and Guspatni (2022) found the same results regarding the effectiveness of using integrated instructional media prompting questions.

N-Gain Test

The N-gain test is used to determine the effectiveness of using discovery learning-based e-modules that are integrated with probing-prompting questions in chemistry learning, especially material on basic chemical laws and voltaic cells. N-gain is the difference between students' pretest and post-test scores, which indicates whether students experience an increased understanding of the material taught in the e-module or not. The following results of the student's N-gain tabulation can be seen in Table 5 and Table 6. And, the average N-gain score is described in graphical form in Figure 1.

Table 4 Paired sample t-test results

Paired sample *t*-test		
Chemical Material	T-count	T-table
Fundamental law of chemistry matter	7.96	1.69
Voltaic cell matter	6,818	2,093

Table 3 Pretest-posttest normality test results

Rated aspects	Chemical Fundamental Law		Voltaic Cell	
	L count	L table	L count	L table
Student pretest scores	0.105	0.161	0.1224	0.19
Student posttest scores	0.128	0.161	0.138623	0.19

Table 5 E-Module N-gain test results on fundamental chemical laws

No	Rated aspects	Values Tab	
		Pretest	Posttest
1	Number of students	30 people	30 people
2	The highest score	65	95
3	Lowest value	20	65
4	Completed amount	0	26
5	Unfinished amount	30	4
Average N-gain		0.68	

Table 6 N-gain test results on voltaic cell material

No	Rated aspects	Values Tab	
		Pretest	Posttest
1	Number of students	20 people	20 people
2	The highest score	60	93
3	Lowest value	27	40
4	Completed amount	0	9
5	Unfinished amount	20	11
Average N-gain		0.52	

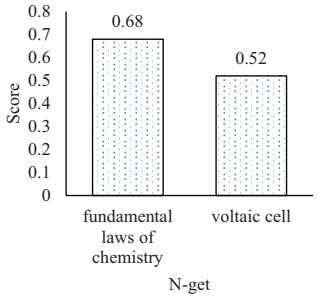

Figure 1 Average N-gain score

Discussion

E-modules are effective if students' ability to assign material increases. The results of the pretest and posttest values were obtained from working on 25 objective questions on basic chemical law and 25 questions on voltaic cells. The effectiveness of the e-module can be seen from the similarity test of the average score of the pretest and posttest results and refers to the score above the KKM (Minimum Completeness Criteria) that has been determined by the school. Therefore, if there are differences in the results of the pretest-posttest average similarity test, the application of the e-module can be said to be effective. Then the results of the pretest and posttest are calculated using the N-gain formula so that the values of 0.68 and 0.52 are concluded in the medium category. It can be concluded that the e-module is effective in high school class test and can be continued to large class test. Previous research has shown that using e-modules for students can increase learning independence in the high category and student learning outcomes in the medium category (Linda et al., 2021). In addition, electronic-based teaching materials that contain interesting learning multimedia can increase students' achievement of knowledge competence (Solihudin, 2018). Good teaching materials can increase student learning interest, which affects student learning outcomes. This was also reinforced by interviews with students after the posttest was carried out. They stated that teaching materials that are integrated with technology and equipped with videos, good pictures, and attractive e-module designs make learning less rigid and more enjoyable. Apart from that, the existence of videos and simple to complex questions (probing-prompting questions) can help them understand the material better and be more focused. A good response from teachers in these schools should be able to trigger the creation of innovative teaching materials that can improve the quality of education in Indonesia. In addition, the teacher also suggested that interactive e-modules such as those that have been developed not only include two materials but other chemistry materials, or even better, e-modules being made for all existing school subjects. The ease of access and the relatively high costs incurred by high schools to obtain knowledge that is packaged interactively have increased interest in e-modules because students from the lower middle class can also use them. From the description above, it can be concluded that the implementation of e-modules based on discovery learning is suitable for high school students because it can increase student learning activity and independence. Data obtained by e-modules can also improve learning outcomes and serve as interesting teaching materials for students. This study case on fundamental laws chemistry and voltaic cell matters proved that the e-module based on discovery learning integrated by probing prompting questions on chemistry learning is effective.

Conclusions and recommendations

Based on the results of the study it can be concluded that an e-module based on the discovery learning model which is integrated with probing prompting questions in chemistry learning is effectively used as alternative teaching material in the learning process. This can be seen from the application of e-modules increasing students' interest and motivation, as well as their learning outcomes. This research recommends Canva's premium software to design attractive e-modules.

Conflict of Interest

The authors declare that there is no conflict of interest.

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