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The Development of Physics E-Module Based on Discovery Learning on Optics Materials in Senior High Schools

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Abstract *– This study aims to develop a physics e-module based on discovery learning that is valid, practical, and effective for high school students. The type of research used was research and development (R&D) with 4-D model research procedures, namely define, design, develop, and disseminate. The participants in this study were 36 students of class XI IPA 1 SMAN 12 Padang. In this study, the initial analysis of the questionnaire was carried out. The data obtained were then analyzed to determine the validity, practicality, and effectiveness of the e-module developed. To assess the validity of the module, two material experts and one media expert were involved, while to find out the practicality level, 36 students and one physics teacher were given their evaluation. Furthermore, the effectiveness of the module was assessed using the N-Gain calculation. The results show that the validation score was 85.46% (very valid category), while the practicality test scored 94.11 percent (very practical category). Meanwhile, the effect of the physics e-module is also quite significant, with the results of the t-test 20.02 >1.68957 and the N-gain calculation producing a score of 0.71. These indicate that the physics e-modules based on discovery learning that has been developed are categorized as very valid, very practical, and effective. Therefore, the use of the discovery learning-based physics e-module is appropriate to improve students' conceptual understanding.*

Keywords: *discovery learning; e-module; optics; research and development*

I. INTRODUCTION

The Ministry of Education, Culture, Research and Technology of the Republic of Indonesia issued a policy to eliminate face-to-face activities in schools and replacing the teaching and learning process at home using an online system (Sahir et al., 2021; Faizah et al., 2021; Susilo & Sofiarini, 2022). Online and offline learning policies are stipulated in Circular Letter Number 3 of 2020 regarding online learning from home in the context of preventing the spread of Covid-19 (Sari et al., 2022). The new policy regarding online and offline learning led all teachers to think of ways to make learning continue as well as it should (Andriani et al., 2021). The covid-19 pandemic also has an impact on the implementation of education

(Intani & Sutama, 2020; Pokhrel & Chhetri, 2021; Karakose, 2021). Ellianawati et al. (2021) argued that during the Covid-19 pandemic, the decline in learning outcomes could also be influenced by the learning process in the classroom and students' motivation. In the learning process during the Covid-19 pandemic, students and teachers are required to carry out online and offline learning processes (Setyaningrum et al., 2021; Koeswanti, 2021; Agung et al., 2022). In practice, when conducting an online learning process, most teachers only send teaching materials in the form of PDF files to class groups, while in offline learning, they apply an emergency curriculum, where learning hours are cut so that they cannot do practical work in the laboratory (Sukarno & Widdah, 2020). In line with that, Sakti and Idamayanti (2021) argued that to develop effective learning, students should also carry out practicums to understand the concept and its application in real contexts.

Furthermore, the results of questionnaires distributed to students of class XI IPA 1 SMAN 12 Padang reveals that most of the students use the material in the form of PDF files when studying with their teachers, both in the online and offline learning process. Learning tends to be teacher-centered, so students are dependent on teachers, which causes students to be less active during the learning process. Meanwhile, during online classes, the teachers only provide material in google classroom so that students are less engaged in the learning process. The textbooks used are still in the form of printed books, causing the teaching materials cannot be applied online and offline learning. Hence, students are still unable to understand the material and learning cannot be carried out optimally.

Based on the description above, an effort to make students more active and interested in learning physics is to develop interesting learning material that can be used during offline and online learning. One of the learning materials is the discovery learning-based physics e-module. This e-module can be used in offline and online learning. According to Munandar et al. (2021) and Ulfa and Sucahyo (2022), e-modules are one of the good learning alternatives for students in the Covid-19 pandemic era because e-modules can help students to learn systematically to achieve competencies that are presented in digital format and can be accessed offline and online.

Sujarwo et al. (2022) suggest that in the Covid-19 pandemic, teachers play their central role as motivators in order to create an interesting learning process for students, while parents act as facilitators. Thus, innovation and optimization of the implementation of education are carried out by providing knowledge from teachers to students through online media. Garad et al. (2021) argue that during the Covid-19 pandemic, electronic media has completely replaced traditional learning, resulting in

many problems related to the lack of effective infrastructure and human expertise. Therefore, discovery learning-based physics e-modules need to be developed so that they can be used as an alternative in overcoming existing problems. This is often expected to actively involve students in discovering and understanding physics concepts. Furthermore, the material that will be taken for the development of an e-physics module based on the discovery learning model is the material for ray optics and optical instruments.

Therefore, this study aims to develop discovery learning-based physics learning e-modules that are categorized as valid, practical, and effective for increasing students' conceptual understanding. The material developed is optics materials for class XI IPA in senior high school.

II. METHODS

This study used research and development design. Research and development is an educational tool carried out by educational institutions through a series of evaluations and is designed to meet the criteria of perfection, quality, or convenience by standard (Said et al., 2021). This development research is expected to produce a product, namely teaching materials in the form of e-learning modules.

In this study, the development model applied was a 4-D model. This model consisted of 4 stages of development called define, design, develop, and disseminate. Fitri et al. (2021) argue that the activities carried out at the define stage are (1) curriculum analysis, (2) concept analysis, and (3) student analysis. In the design stage, the product is designed according to discovery learning syntax. In the develop stage, we search for validation and practicality level of the e-modules. The validation level was assessed by 2 material experts from Physics Education Study Program, Universitas PGRI Sumatera Barat and 1 media expert from Informatics Education Study Program, Universitas PGRI Sumatera Barat. The practicality level was collected through the questionnaires distributed to students in class XI IPA 1 and physics teachers at SMAN 12 Padang.

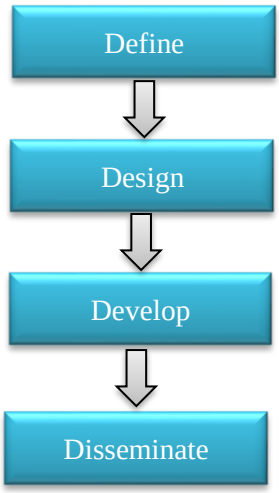

Figure 1. 4D Model stages of development

Furthermore, in the disseminate stage, the physics module based on discovery learning model was distributed in class XI IPA 1 SMAN 12 Padang, then pretest and post-test questions were given to students, aiming to find out whether this e-module was

effective for class XI students. Suebsing and Nuangchalerm (2021) argue that the use of pretest and post-test designs to study the development of e-modules in offline and online learning was to explain the process and product of the program.

The research subjects were 1 physics teacher and 36 students of class XI IPA 1 SMAN 12 Padang. The type of data needed in this research was the result of the initial analysis, validity, practicality, and pretest and post-test questions to determine the effectiveness of the product. In addition, the data in this study were also collected based on existing documents in the form of an analysis sheet on the relationship between core competency and basic competency, as well as the learning syllabus used by teachers in class XI IPA 1.

The data analysis technique was carried out quantitatively. Safitri et al. (2020) argue that this stage aims to explain something so that the data is categorized as valid, practical and effective. Based on the description above, the analysis used is validity analysis, practicality analysis, and effectiveness analysis. The data analysis method used is expert validation analysis and practical analysis by students and teachers.

The results of validation analysis from all aspects assessed from the e-module were then analyzed using the formula (Riduwan, 2013). The analysis of the validity of the research product was carried out in the following stages:

a. Calculating the score of each validator using the formula:

$$NA = \frac{S}{SM} \times 100\% \qquad 1)$$

with description,
NA = The final validation score of each validator
S = Score obtained
SM = Maximum score

b. Calculating the average score of the final scores of all validators

$$\bar{X}_{NA} = \frac{\sum NA_i}{n} \qquad 2)$$

With description,
$\bar{X}_{NA}$ = The average score of all validators
NA_i = The final score of the validators assessment
n = number of validators

c. Determining the validity level using modified criteria from Riduwan (2013) as follows:

Table 1. Product validity criteria

Intervals (%)	Category
0-20	Very Invalid
21-40	Less valid
41-60	Quite Valid
61-80	Valid
81-100	Very Valid

From Table 1, it can be summarized that the e-module is declared qualified and suitable for use in the field if it meets the valid to very valid criteria with a percentage range between 61 and 100.

In the practicality assessment of all aspects based on the questionnaire responses to the use of e-modules by students and teachers, then it is analyzed using the formula. Practical data analysis is carried out in the following steps:

a) Recapitulating the results of the questionnaire distribution

b) Calculating practicality values

$$Practical = \frac{Total\ score}{Maximum\ score}\ X\ 100\% \quad 3)$$

c) Finding the mean of all respondents

$$\bar{X}_{NA} = \frac{\sum NA_i}{n} \quad 4)$$

With description,
$\bar{X}_{NA}$= average value of all respondents
NA_i= the final score of the i-th respondent's assessment
n= number of respondents

d) Interpret the results obtained using the modified criteria of Riduwan (2013) in the following Table 2.

Table 2. Product practicality criteria

Intervals (%)	Category
0 - 20	Very Impractical
21 - 40	Not Practical
41 - 61	Practical enough
61 - 80	Practical
81 - 100	Very Practical

Based on Table 2, it can be concluded that the e-module that has been tested is feasible to be applied and further developed when it meets the criteria of practical to very practical, achieving a practicality score between 61 and 100.

Meanwhile, the effectiveness of the developed teaching materials was analyzed through the measurement data of student learning outcomes. Using t-test analysis techniques and N-gain test analysis, this study aims to measure the average increase of students' outcomes in learning physics. Researchers analyzed all test results, both the tests used before the media was given and after the media was given to students in class XI IPA 1 at SMAN 12 Padang, by using the formula suggested by Arikunto (2010).

1) Calculating t-value (t-test)

$$t = \frac{Md}{\sqrt{\frac{\sum x^2 d}{N\,(N-1)}}} \quad 5)$$

Information;

Md = Mean of deviation (d) between post-test-pretest
xd = difference between deviation and mean deviation
N = Number of subjects
df = or db is N-1

With the criteria, if the value $t_{count} > t_{table}$, then there is an effect of e-module on learning outcomes. Conversely, when the value $t_{count} < t_{table}$, then it can be seen the probability value (not significant) or there is no effect of e-module on learning outcomes.

Furthermore, the N-Gain test was carried out to determine the increase of students' learning outcomes, which can be interpreted using normality gain. Sundayana (2014) argues that normality gain is formulated in the following equation:

$$g = \frac{S_{post} - S_{Pre}}{Score\ Maxsimal - S_{pre}} \quad 6)$$

Information;

g = gain score normality
S_{Pre} = Pre-test mean score
S_{post}= Post-test mean score

Table 3. Gain score criteria

Score Gain	Interval
N-gain>70	High
0,30 ≤ N-gain < 0,70	Medium
0,00 < N-gain < 0,30	Low

To see the interpretation of product effectiveness, an interpretation table is used

as shown in Table 4 below (Sundayana, 2014).

Table 4. Criteria for interpreting the effectiveness of N-gain

Presentation	Interpretation
0-39	Very ineffective
40-55	Ineffective
56-75	Effective
75-100	Very effective

Based on Table 3 and Table 4, it can be concluded that the e-module is feasible to be applied when it meets the effectiveness standard in the score range of 0.30 N-gain <0.70 to N-gain>70 and the percentage range from 56 to 100.

III. RESULTS AND DISCUSSION

At the define stage, namely analyzing the curriculum, concepts, and students, initial analysis data was obtained from interviews with teachers and the distribution of questionnaires to students. The results obtained from the initial analysis applied to teachers and students are that the average student's ability is still classified as understanding physics subject matter. This is due to several factors, including the way teachers explain the lesson and the language of the book being less accessible to students. The material presented will be easily accessible by students if they have connected with everyday phenomena around the students' environment. Therefore, the discovery learning model is applied to the developed e-module so that it can support students' understanding of learning.

The define stage was used as a basic during the design stage. This e-module is designed to have a structure consisting of a cover, acknowledgment, table of contents, concept maps, instructions for use, basic competencies and indicators, learning activities that are in line with the syntax of the discovery learning model (simulation, problem statement, data collection, data processing, verification, generalization), exercise, glossary, bibliography, and an answer key. The example form of the e-module design is presented in Figure 2:

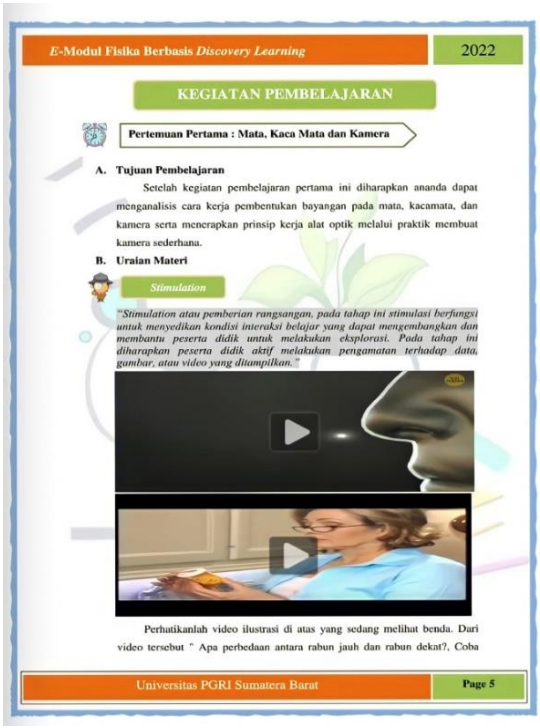

Figure 2. Physics e-module based on discovery learning

After the physics e-module was declared feasible for testing by all validators, then an analysis of the validity scores of each

validator was carried out. The general validity of Young's modulus can be derived from the results of data analysis, as shown in Table 5.

Table 5. Experts validation results in general

Assessment aspect	Material expert validation (%)		Media expert validation (%)	Average validation percentage	Validation category
Content eligibility	75.00	88.80	-	82.14	Very valid
Language eligibility	75.00	100.00	-	87.50	Very valid
Serving eligibility	75.00	90.90	-	82.95	Very valid
Media	-	-	89.28	89.28	Very valid
Average				**85.46**	**Very valid**

Table 5 shows that physics e-module based on discovery learning are classified as very valid with a share of 85.46%. This indicates that the developed discovery-based physics e-module has been declared suitable for testing in classroom activities.

Physics e-module verification aims to determine whether the module being developed is of good quality. Oktasari et al. (2019) argued that good and quality media selection should be media that are validated by some recognized experts. In this study, the media is a physics e-module based on discovery learning. Based on data analysis from 2 material expert validators and 1 media expert validator, the e-module designed is classified as highly effective in proportion 85.46%. Then, the real test of this e-module was used during learning by a teacher and 36 students in 3 learning activities at Class XI IPA 1 SMAN 12 Padang. The results are shown in Table 6.

Table 6. The results of the implementation of the developed e module

Assessment aspect	Practical presentation		Average percentage score	Practicality category
	Teacher	Student		
Ease of use	92.85	91.55	92.50	Very practical
Time required	100.00	89.87	94.93	Very practical
Easy to interpret	93.75	92.18	92.96	Very practical
Have the same equivalence	100.00	93.00	96.50	Very practical
Average	**96.65**	**91.65**		**Very practical**
Practical category	**Very practical**	**Very practical**	**94.11**	**Very practical**

Table 6 depicts that the overall practicality of the e-modules is 94.11%. Thus, practical questionnaire results indicate that e-modules are generally categorized as highly practical. This means that the e-module is very practical in terms of ease of use, ease of interpretation, and comprehension.

Fransisca, (2017) argues that field tests in research aim to determine the feasibility level of a product and make it usable by students and teachers through its ease of use. Yanti et al. (2022) argued that the higher the practicality value, the more practical it is to use it in the learning process. Based on this statement, it can be concluded that the product developed is practical to use and developed for wider use.

In the dissemination stage, the effectiveness of the learning-based discovery physics e-module was assessed. The effectiveness result is seen from the pre-test and post-test scores, where the pre-test questions were distributed to students before the product is used, while the post-test questions were distributed to students after using e-modules during the physics learning process on optical instruments material. The development stage aims to produce an effective discovery learning-based physics e-module. The effectiveness of the product was analyzed through the t-test and N-Gain test. The results of the t-test analysis obtained were described as follows.

Table 7. T-test results

Parameter	Treatment	Information
t-test	t_{count} = 20.02 t_{table} (5%) 0.05 = 1.68957	$t_{\text{count}} > t_{\text{table}}$, then the results of this t-test are significant (the use of e-modules affects students' learning outcomes)

In Table 7, it can be seen that t_{count} is 20.02 and t_{table} (5%) 0.05 is 1.68957. Because the $t_{count} > t_{table}$, it can be concluded that the use of e-modules in the physics learning process for class XI IPA 1 at SMAN 12 Padang can significantly affect students' learning outcomes. Furthermore, the analysis of the N-Gain test is carried out, which aims to see the effectiveness of the e-module. The N-gain test that has been obtained is described as follows.

Table 8. Analysis of N-gain test

Average pre-test score	Average post-test score	N-Gain	Gain
46.36	85.78	0.71	73.27
Description		**High**	**Effective**

Table 8 shows that the average value of the pre-test of students' learning outcomes before learning using e-modules was carried out by a teacher is 46.36. Furthermore, it increased in the post-test to an average of 85.78. The gain in class XI IPA 1 is worth 73.27 with an effective category, while the value of N-gain in class XI IPA 1 shows understanding or mastery of concepts in optical instruments with a value of 0.71 with a high category. Thus, it can be concluded that the use of a discovery learning-based physics e-module is effectively used during the physics learning process.

Based on the explanation above, it can be said that the validity, practicality, and effectiveness determine whether the product quality has been improved so that it can be implemented. Hartini et al. (2018) argue that the selection of superior and quality

educational media or materials must be verified by professionals or experts. In line with that Ntobuo et al. (2018) argue that the higher the efficacy value of the instrument, the data obtained from the research will be more accurate. From the statement above it can be concluded that if the value of effectiveness is high, then the measuring instrument is reliable and valid. This means that the developed e-module is valid and can be trusted based on the percentage of validity obtained. In addition, the feasibility of a product is also determined by the practicality of the product. Abdurrahman et al. (2018) argue that the higher the practical value of the product, the more practical it will be to use it in the learning process. From the statement above, it can be concluded that overall, e-modules should be practical and feasible during the learning process.

After the product is stated as valid and practical, the product effectiveness test is carried out. Hastuti et al. (2021) argue that learning effectiveness is a measure of the success of a process of interaction between students and teachers in educational simulations to achieve learning objectives. From the statement above, it can be concluded that, in general, the e-module received a good response from the students, as seen from the results of the pretest conducted on the students. Products in the form of teaching materials that have been said to be valid, practical, and effective are included in the category for validators, teachers, and students. So this teaching material is feasible to be applied during the learning process. From the discussion, it was found that discovery learning-based e-modules for class XI science in high school were developed to be valid, practical, and also effective to be applied in the classroom in the teaching and learning process at school.

In a previous study, Sasahan et al. (2017), had also carried out research entitled "development of a digital physics module based on discovery learning on the subject of straight motion kinematics" where the practical results can be proven that this method is practically applied during the learning process. The results are similar to this study, where the practicality was categorized into very practical e-modules and can be applied during the physics learning process for class XI on optical instruments. In this study, it can be seen that when the developed e-module is implemented in the learning process, it can increase students' interest in learning, and provide flexibility for students to study independently. This makes students more able to understand physics concepts, and students can carry out simple experiments in class during the teaching and learning process

IV. CONCLUSION AND SUGGESTION

Based on the results of the study, it can be concluded that the e-module physics based on discovery learning that was developed is categorized as valid, practical, and effective. The validity and practicality values obtained were 85.46% and 94.11%, respectively. Then, the value of effectiveness is obtained based on the results of the t-test where the t-count (20.02) is greater than the t-table (1.68957), which means that the physics e-module based on discovery learning that is being developed is effectively used during the learning process on optical material.

This research has several weaknesses including only conducting field trials at 1 school and the physics e-module which was developed only on the topic of optics. Therefore, this research is open to future researchers to develop physics e-modules for different materials. In addition, field trials need to be carried out in several different schools with a large number of students so that the data obtained is more accurate.

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