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Developing Science Electronic Module Based on Problem-Based Learning and Guided Discovery Learning to Increase Critical Thinking and Problem-Solving Skills

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***Abstract*—The Development research conducted to develop science electronic modules based on Problem Based Learning and Guided Discovery Learning to improve critical thinking skills and problem solving. The ability of critical thinking and problem solving needs to be possessed by students because in the 21st century students are required to have various skills. These skills will build the concept of thinking from simple thinking to high-level thinking. The availability of student books in printed form also has limitations in the presentation of material. So that the limitations of this print media open opportunities for the integration of a supplement of teaching materials with the latest information technology to support the achievement of 21st century skills. So researchers developed a teaching material supplement in the form science electronic module based on Problem Based Learning and Guided Discovery Learning to improve critical thinking skills and problems solving.The model used in this research is the R&D model that adapts from ADDIE model. Assessment for product advisability is assessed by material experts and media experts, where the assessment is carried out using an assessment questionnaire sheet. In this research also conducted a limited test to see the readability of the E-Module. Based on the assessment of experts, it can be seen that Science E-Module based Problem Based Learning and Guided Discovery Learning is reasonable to applied in science learning to improve critical thinking skills and problem solving.**

Keywords: E-module, problem-based learning, guided discovery learning, critical thinking, problem solving

I. INTRODUCTION

The development of the world of Education requires teachers to know how to package learning to be more interesting and the skills of students can be facilitated. Students 'skills will be realized if the initial knowledge is used as a basis for learning, but sometimes the teacher ignores the students' initial knowledge. The intial knowledge will actively foster high-level cognitive skills. [37]. Learning science does not only require students in their cognitive, but there are some skills that must be cultivated.

Research conducted by Arifah P., Zuhdan K., &Insih W [16] mentioned that science learning can affect the process skills if it integrates the science domain. Science learning consists of five domains are knowledge, science processes, creativity, attitudes, applications and connections. If these five domains can be realized, science learning will become more meaningful. This means that learning not only emphasizes the cognitive aspects but also other skills. These skills are the basis of students in facing the challenges of the 21st century.

21st Century life requires various skills to be mastered so that the world of education is expected to be able to prepare students to master a variety of 21st century skills. Based on the results of research conducted by the OECD, three dimensions of learning in the 21st century are obtained information, communication, ethics, and social influence. Creativity is also an important component in order to successfully face a complex world. Partnership for 21st Century Learningexplains that 21st century skills include (1) life and career skills, (2) learning and innovation skills, and (3) information media and technology skills. [20]

The application of the 2013 curriculum in the world of education today is an embodiment of the 21st century, so students are expected to be optimally facilitated in facing global challenges. The 2013 curriculum is an embodiment of 21st century skills that emphasizes the application of scientific approaches in the learning process. This curriculum demands the application of high thinking skills (HOTS). Problem based learning and guided discovery learning are learning models recommended by the 2013 curriculum for use in learning. Guided discovery learning is a learning model that requires students to learn actively by conducting their own findings and investigations and inferring them, in line with this problem based learning is also a learning model that is student-

centered where students learn through problem solving that is not structured [33]. The ability to think critically and problem solving needs to be owned by students because in the 21st century students are required to have a variety of skills in particular are thinking skills that are creative and innovative; think critically, solve problems, determine students' decisions and metacognitive abilities. This skill will build the concept of thinking from simple thinking to higher order thinking.

In addition, the 2013 curriculum shows that the existence of teaching materials is one of the important elements in learning which will facilitate teachers and students. The government has sought to meet the needs of teaching materials by providing Teacher Books and Student Books. Based on the results of interviews with junior high school science teachers it was found that in learning activities teachers still use lecture learning models and rarely use learning models that are recommended by the government. In addition, based on an analysis of Teacher Books and Student Books that have been conducted, 21st century skills competencies, namely critical thinking and problem solving that are important for students to master, have not yet been fully raised. Student books in printed form also have limitations in the presentation of material. The limitations of print media open up opportunities for the integration of a supplement of teaching materials with the latest information technology to support the achievement of 21st century skills.

Considering the importance of the existence of teaching materials, then a researcher developed a supplement of teaching material in the form of an electronic module based on a scientific approach that supports mastery of 21st century skills. The scientific approach that will be applied in learning models are problem based learning (PBL) and guided discovery learning. 21st Century skills that are the focus of research are critical thinking and problem solving.

II. SCIENCE MODULE ELECTRONICS BASED ON PROBLEM BASED LEARNING AND GUIDED DISCOVERY LEARNING

A. Electronic Module

Modules are teaching materials that are arranged systematically in communicative language for students so that they can learn independently with minimal guidance from educators [24]. The develops of information and communication make a print modules are transformed into electronic modules (e-modules), which successfully shifts print media dominance. Revealed that e-module is an independent teaching material that is equipped with multimedia support.[19]

E-modules become effective and efficient digital learning media to help students in learning activities [10]. E-modules as learning media developed from print media, have criteria that are not much different from modules in general. The learning module according tohas five characteristics, are : Self instruction. self contained. stand-alone, adaptive and user friendly [6].

B. Problem Based Learning

Problem based learning is a learning method that makes students the center of learning through solving unstructured problems [33]. Problem based learning helps construct knowledge when students activate knowledge in the initial discussion [26]. Problem-based learning is an innovative learning model and provides active conditions for students, so that it is relevant to be used in learning with the characteristics of students who are passive during learning [40]. Problem based learning is also seen as a superior learning model in making students accustomed to dealing with phenomena and problems [2]. This is relevant to that delivered by NafiahNafiah [17] and Nugroho &Karyanto [18] that problem-based learning is learning that utilizes real-world problems as objects for students in learning about how to think critically, solve problems, and gain knowledge and essential concepts from the lesson.

C. Guided Discovery Learning

Discovery learning is a learning model which in its implementation requires students to learn actively by making their own discoveries, self-investigating, and concluding. So that students' memories will last long and will not be easily forgotten because the discovery is done by themselves [13]. Guided discovery learning is learning that involves students actively during the learning process, where students answer teacher questions. Teachers guide and students do discovery [12]. Eggen mentions the steps taken in guided discovery learning, are (1) Phase 1: introduction, (2) Phase 2: open-ended phase, (3) Phase 3: convergent, (4) Phase 4: closure and application [8].

D. Critical Thinking Ability and Problem Solving

Permendikbud also explains that the ability to think critically is one part of the goals of education, where one of the abilities expected in learning is the ability to think critically [22]. Critical thinking is a rational and reflective way of thinking to decide what to believe or do which is sometimes described as a teaching goal [28]. Rational which means having beliefs and views as well as having relevant evidence, while Reflective means being able to consider diligently all alternatives of solving solutions before making a decision [19]. In addition, critical thinking is a process of rational thinking in looking at something [15].

Problem solving is a mechanism to identify a solution of a problem, in addition to referring to the activities of remembering and learning, problem solving is also needed for critical thinking, creative thinking, and effective communication [1]. W. Gulodefines problem solving is the process of thinking and finding a solution to the problems faced [38]. The ability to solve problems is a skill that a person has in

applying knowledge obtained previously in solving a problem, of course, with different situations [34].

III. RESEARCH METHOD

This research is a type of Research and Development (R&D) research, which adapted from the ADDIE model consisting of Analyze, Design, Develop, Implement, and Evaluate. The products to be produced in this research are Science E-Module based on PBL to improve critical thinking skills and ScienceE-Module based ono Guided Discovery Learning to improve problem solving skills. Development is carried out in stages to produce products in the form science E-Module that are suitable for use. The making of science E-Module was developed using moodle software.

In this development research activity, the first activity carried out was analyzing needs by observation and interviewing school teachers about how to use teaching materials and learning models, then analyzing curriculum and Teacher Books and Student Books and analyzing KI and KD which subsequently determined the science material to be used . After that it was concluded that the need for the development of science electronic modules based on problem based learning and guided discovery learning to improve critical thinking skills and problem solving.

The second stage is the planning or design of the product, where at this stage the product is made using moodle software [14]. which is operated online and consists of: (1) Cover (initial page), in this section includes the title, university logos, login pages (https://emodul.online/) and (https://emodul.site), an overview of learning materials for each meeting and product descriptions; (2) Dashboard, in this section consists of my courses that include material at each meeting, summary and bibliography [30]. In learning activities in electronic modules are made based on the steps of the problem based learning model and guided discovery learning. Then the next step is development the realization of the activities in the previous stage. Product design that has been prepared, developed based on: (1) the concept of media, is the process of selecting or developing media based on context, resources, working conditions, culture and practicality [10].

Calculation of the score from each aspect of the assessment provided by the assessor using equation 1:

$$x = \frac{\Sigma x}{n} \qquad \text{(Equation 1)}$$

Information:
Σx : average score
x : total score of each assessor for a particular component
n : number of assessors

The quality of the product developed will be known by changing the original data in the form of quantitative scores into qualitative data (intervals) with a scale of five. The conversion of scores into interval data is in accordance with the opinion of Widoyoko as shown in Table 1 [39].

TABLE I. DETERMINATION OF PRODUCT CRITERIA INTERVALS

Interval Scores	Values	Category
$X > (\overline{X}_i + 1{,}8Sb_i)$	A	Very High
$(\overline{X}_i + 0{,}6Sb_i) < X \leq (\overline{X}_i + 1{,}8Sb_i)$	B	High
$(\overline{X}_i - 0{,}6Sb_i) < X \leq (\overline{X}_i + 0{,}6Sb_i)$	C	Enough
$(\overline{X}_i - 1{,}8Sb_i) < X \leq (\overline{X}_i - 0{,}6Sb_i)$	D	Low
$X \leq (\overline{X}_i - 1{,}8Sb_i)$	E	Very Low

Information:
X : empirical score (score achieved)
$\overline{X_i}$: ideal mean (1/2 (maximum score + minimum score)) Sb_i : ideal standard deviation (1/6 (maximum score minimum score))

IV. RESULTS AND DISCUSSION

A. *Science E-Module Based on PBL to Improve Critical Thinking Skill*

In this research development activity the data obtained include: the advisability data of the E-Module and the readability of the E-Module. The advisability of this E-Module is determined through the results of the expert validation assessment. There are 4 components validated by experts which include: appearance, learning material, presentation, and language. The steps for data analysis include: a) tabulating all data obtained from each product validation sheet and assessment instrument; b) calculate the average score of each aspect of the assessment given by the assessor using equation 1; and c) change the average score to a category value. The following analysis results are obtained:

TABLE II. RESULTS OF ADVISABILITY ANALYSIS OF SCIENCE E-MODULE MATERIAL BASED ON PROBLEM BASED LEARNING

No	Validator	Actual Score (X)	Interval	Category
1	Material Expert	24	X > 22,40 17 <X ≤ 22 11<X ≤ 17 6<X ≤ 11 X≤ 6	A. Very Good
2	Teachers (Practitioner)	56	X > 55 44<X ≤55 34<X ≤44 23 <X ≤34 X ≤ 23	A. Very Good
3	Peer Friends (Practitioners)	58		A. Very Good

Based on the data in table 2 it can be seen that the product that has been developed in the form of a science e-module based on problem based learning on environmental pollution material for the material aspect is declared feasible by expert lecturers with the interval obtained 24> 22.40 and very good category. This product evaluation sheet in terms of material includes material and language aspects. Suggestions

obtained from material experts in the article section and description of the material added images relevant to everyday life, typos and spacing in writing. These suggestions have been corrected through a revision process. Furthermore, for the practitioner test by science subject teachers, values obtained at intervals obtained 56> 55 and are categorized very good as well as giving suggestions about letter sizes that are too small. The suggestion has been fixed. The practitioner test by peers that was declared feasible with the interval obtained 58> 55 and very good category. The product practitioner test sheet consists of material and language aspects which include the conformity of the material to the curriculum, the suitability of the learning material and learning objectives, the suitability of the language with the level of student ability, the use of terms in the material and the use of punctuation.

TABLE III. RESULTS OF ADVISABILITY ANALYSIS OF SCIENCE E-MODULE MEDIA BASED ON PROBLEM BASED LEARNING

No	Validator	Actual Score (X)	Interval	Category
1	Media Expert	14	X > 14 10< X ≤ 14 7< X ≤10 3< X ≤ 7 X ≤ 3	B. Good
2	Teachers (Practitioners)	26	X > 25 20< X ≤ 25 16< X ≤ 20 11< X ≤ 16 X ≤ 11	A.Very Good
3	Peer Friends (Practitioners)	27		A. Very Good

Based on table 3, it can be concluded that sciencee-module based on problem based learning by media experts is declared feasible with intervals obtained 10 <14≤14 and categorized as good. The aspect of assessment for the media aspect is the appearance of the interface and presentation which includes the e-module section, the e-module position in moodle, PBL syntax, aspects of critical thinking ability. The product validation sheet by the media expert has several suggestions including a picture on the e-module including the source, adding a product description, some language editors being corrected and a video not linking on YouTube. These suggestions have been adjusted to the product through a revision process.

TABLE IV. EXPERT TEST VALIDATION RESULTS FOR PRETEST AND POSTTEST QUESTION CRITICAL THINKING SKILL

No.	Aspect	Actual Score (X)	Interval	Category
1.	*Pretest*	65	X>67,2 55,4<X≤67,2 41,6<X≤55,4 28,8<X≤41,6 X≤28,8	B. Good
2.	*Posttest*	63		B. Good

Based on the results of the instrument validation, the ability to think critically at table 4 can be concluded that the instrument in the form of pretest and posttest questions is appropriate to be used according to material experts, with intervals obtained from pretest questions is 55.4 <65≤67.2, which are categorized as good. While for the posttest questions, an interval of 55.4 <63≤67.2 was obtained which is categorized as good. From this validation we get general suggestions for improving the writing of letters, punctuation and terms in the problem. These suggestions have been improved through a revision process. After going through the validation of the experts both material and media and the revision process, the science E-Module product is limited to being tested. A limited trial was conducted to see the readability of students towards the developed e-modules. This readability test was conducted on 6 students. The results of limited trials (readability) can be seen in table 5.

TABLE V. RESULTS OF THE LIMITED TRIAL ASSESSMENT (READABILITY)

No.	Students	Actual Score (X)	Interval	Category
1.	R1	68	X > 63 51<X ≤ 63 39<X ≤ 51 27<X ≤ 39 X ≤ 27	A.Very Good
2.	R2	68		A. Very Good
3.	R3	66		A.Very Good
4.	R4	59		B.Good
5.	R5	64		A. Very Good
6.	R6	66		A. Very Good
Average		65		A. Very Good

Based on the data obtained in table 5, it can be concluded that the average trial is limited to see the readability of students, amounting to 6 students in science e-module based on PBL in improving critical thinking of students who developed very good with the interval obtained is 65> 63. When viewed individually, in the readability test only R4 students scored 59 with intervals of 51 <59≤63 and were categorized as good. As for the other students, they get grades with intervals greater than 63 (X> 63). In addition, the summary of comments and suggestions obtained from this test is that I like watching videos, writing questions too small and I want to add more videos. These comments and suggestions have been adjusted and improved through the revision process.

B. Science E-Module Based on Guided Discovery Learning to Improve Problem Solving Skill

Research on the development of science E-Module based on guided discovery learning, in each meeting learning activities are made according to the guided discovery learning syntax accompanied by additional features such as videos, images, posters, etc. The first syntax in learning guded discovery learning is stimulation which is realized in the form of apperception, then the second syntax is the problem statement which is realized in the form of science investigation, the third syntax of data collection which is manifested in the form of activity, let us learn,the fourth syntax is data processing which is realized in important info activities, the fifth syntax is verification which is realized in the form of proven activities, then the last syntax is generalization which is realized in the finished activity. The development of this e-module

needs to be carried out by an expert assessment and a limited test of Science E-Module so that the product is suitable for use. As for the results of the assessment of the experts are as follows:

TABLE VI. RESULTS OF ADVISABILITY ANALYSIS OF SCIENCE E-MODULE MATERIAL BASED ON GUIDED DISCOVERY LEARNING

No	Validator	Actual Score (X)	Interval	Category
1	Expert Material	28	X > 24,8 18,6 <X ≤ 24,8 12,4 <X ≤ 18,6 6,14 <X ≤ 12,4 X≤ 6,14	A. Very Good
2	Teacher (Practitioner)	28		A. Very Good
3	Peer Friends (Practitioners)	30		A. Very Good

Based on the results of the advisability analysis of the Science E-Module based on Guided Discovery Learning from material experts and teachers obtained values at intervals of 28> 24.8 with very good categories then from peers grades with intervals of 30> 24.8 with very good categories. Found some suggestions from the validator that the cases presented are better derived from the surrounding environment and video presented reveals from the macro to micro case.

TABLE VII. RESULTS OF ADVISABILITY ANALYSIS OF SCIENCE E-MODULE MEDIABASED ON GUIDED DISCOVERY LEARNING

No	Validator	Actual Score (X)	Interval	Category
1	Media Expert	10	X > 9,6 8,6 <X ≤ 9,6 4,8 <X ≤ 8,6 2,4 <X ≤ 4,8 X≤ 2,4	A. Very Good
2	Teacher (Practitioner)	11		A. Very Good
3	Peer Friends (Practitioners)	12		A. Very Good

Based on the results of the advisability analysis of the science E-Module based on Guided Discovery Learning obtained by media experts the value at intervals of 10> 9.6 with very good categories then from teachers obtained values at intervals of 11> 9.6 with very good categories as well as from peers obtained values with intervals of 12> 9.6 with very good categories. Expert give a variety of suggestions from the validator that is expanded the scope of the material, the need for multimedia variations, the need for web dynamism so that it is not monotonous and boring.

TABLE VIII. EXPERT TEST VALIDATION RESULTS FOR PRETEST AND POSTTEST QUESTIONS PROBLEM SOLVING SKILL

No.	Aspec	Actual Score (X)	Interval	Category
1.	*Pretest*	58	X>50,4 40,8<X≤50,4 31,2<X≤40,8 21,6<X≤31,2 X≤21,6	A. Very Good
2.	*Posttest*	57		A. Very Good

Based on table 8, the results of the validation test of material experts in the pretest and posttest questions can be seen that the assessment instrument in the form of this matter is appropriate to be used according to the material expert. In the pretest of problem solving skill has interval is 58> 50.4 with a very good category. Then in the posttest questions the interval is 57> 50.4 and it is in the very good category. There are also suggestions from material experts that in the matter there is still typo writing and there are pictures that have not been given the source. This suggestion has certainly been improved through the revision process. Next is a limited test carried out on the E-Modul IPA. This is done to determine the readability of the E-Module. This limited test was conducted on 6 students. Following are the results of the E-Module readability analysis:

TABLE IX. RESULTS OF THE LIMITED TRIAL ASSESSMENT (READABILITY)

No.	Students	Actual Score (X)	Interval	Category
1.	R1	54	X > 44,8 33,6 <X ≤ 44,8 22,4 <X ≤ 33,6 11,3 <X ≤ 22,4 X ≤ 11,3	A.Very Good
2.	R2	56		A.Very Good
3.	R3	52		A.Very Good
4.	R4	56		A.Very Good
5.	R5	53		A.Very Good
6.	R6	54		A.Very Good
Average		54,2		A.Very Good

Based on the results of the analysis of the limited test obtained an average interval value of 54.2> 44.8 with a very good category and with some suggestions and comments from students. Some students said that learning by using this E-Module was very fun because the learning included video but there were some words that were difficult to understand, and there was writing that was too small. Based on comments and suggestions from these students, the researchers made improvements.

Based on the results of the validation analysis of experts, it can be seen that the science E-Module based on guided discovery learning is feasible both in terms of material and media and feasible in limited trials. So it can be used to be implemented on a large scale in improving problem solving skills. Learning activities will be more effective if done using electronic learning media.

V. CONCLUSIONS

The conclusions from this development research are as follows: 1) based on data analysis that has been carried out thatScience E-Module Based on Problem Based Learning and Guided Discovery Learning is feasible to use both in terms of material and in terms of media with good categories, 2) based on limited product trialsScience E-Module Based Problem Based Learning and Guided Discovery Learning in terms of student readability is feasible to use for stages implemented on a wide scale to improve Critical Thinking Skill and Problem Solving.

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