International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

Vol. 36 No. 1 December 2022, pp. 116-126

Improving Students' Mathematical Critical And Creative Thinking Skills Through Problem Based Learning (PBL) E-Module Development

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Abstract – The current curriculum is the 2013 curriculum. In the cognitive domain of this curriculum, students are required to be able to think actively, by focusing on observing critical and creative thinking skills. Mathematics learning is learning that emphasizes solving problems, so participants must be able to think critically and creatively in the learning process. One of the most difficult math material is comparison. SMP Negeri 4 Padang is a school that has an average PH value in mathematics on comparative material which is relatively low. This is because the teaching materials used in the learning process are less attractive and have not been able to hone students' critical and creative thinking skills. One way to overcome this problem is to make interesting teaching materials in accordance with the times. Interesting teaching materials can be in the form of *E-Modules,* then to hone critical and creative thinking skills students can apply *problem-based learning* in the *E-module* . The type of research used is research and development or *research and development* (R&D). The development model used in this study is the plomp development model. The results of this study are that *the E-module* is valid and practical, then the average test results for students' mathematical critical thinking abilities after being tested are 84.8% in the very critical category, while the average test results for students' mathematical creative thinking abilities after being tested is 87.7% with a very creative category. This shows that *e-module* model *problem-based learning* can assist students in finding comparative concepts. Therefore it can be said that *e-module* can be categorized in the effective category.

Keywords – E-Module, Problem Based Learning, Critical Thinking, Creative Thinking

I. INTRODUCTION

Curriculum has a very important role in the success of an education. This is in line with the opinion of Mulyadin (2016), who explains that the curriculum is an important part of the process of providing education. The current curriculum is the 2013 curriculum. The 2013 curriculum was prepared by the government in facing 21st century learning. In the cognitive domain of this curriculum, students are required to be able to think actively, by focusing on observing students' critical and creative thinking skills in the learning process.

Critical thinking is an important topic in the era of modern education. Critical thinking can be used as a thought that is always curious about a problem that occurs so that it will continue to reach the right truth. Zubaidah (2015) states that critical thinking in learning is used to assess and determine opinions towards scientific truth. Meanwhile (Johnson, 2014) states that creative thinking is a mental activity that fosters original ideas and new understandings.

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The Ministry of Education and Culture (2016) explains that in the 21st century, students must be able to develop Higher Order Thinking Skills (HOTS). Students' critical thinking skills must be developed to analyze, evaluate and draw conclusions in solving a problem, especially in everyday life. Students are also required to be more active and creative. Referring to the above, learning mathematics is learning that places more emphasis on solving problems, so students are required to be able to think critically and creatively.

Mathematics learning in class VII for one year for Junior High School (SMP) contains 9 materials, one of which is the comparison in the even semester. Through this learning students can use comparisons or ratios to compare the size of an object with other objects. The size of the object in question can be in the form of length, speed, mass, time, many objects, and so on (Ministry of Education and Culture, 2019). However, Rahmawati (2015) explained that students had difficulty understanding mathematical concepts, especially comparative material in class VII.

Comparisons in mathematics relate to problem solving and calculating activities in domains involving fractions, percents, speed, geometry, algebra, probability, statistics and congruence (Dole, Wright, Clarke & Campus, 2009). Rahmawati (2015) stated that although it is often used in everyday life, the concept of comparison is not easy. A study in Australian middle-year numeracy students found they experienced difficulties when applying ratios and proportions. Students experience difficulty in determining which is a comparison of value (price) and which is a comparison of value (reversed in price).

Based on the results of interviews conducted with several mathematics teachers from various junior high schools in Padang City on September 8-10 2021, namely Padang 4 Public Middle School, Padang 6 Public Middle School, Padang 32 Public Middle School which explained that students still had many difficulties in solving comparison problems. This is seen based on the average value of the Mathematics Daily Assessment (PH) on comparative material. This is due to the lack of understanding of students in the concept of comparison itself, especially in solving problems. Furthermore, an interview was conducted with a class VII mathematics teacher at SMP Negeri 4 Padang, the teacher stated that one of the causes of low student mathematics learning outcomes was the lack of attractive learning resources used especially during the current Covid-19 pandemic. This is in line with the statement (Nurrita, 2018) stating that interesting learning tools can improve learning outcomes and students' interest in learning mathematics.

One of the schools that received a relatively low average PH in mathematics on comparison material was Padang 4 Public Middle School. During the Covid-19 pandemic, Padang 4 Public Middle School used the *geschool* to provide materials, assignments, and PH. This application presents a summary of material and questions in an objective form so that students' critical and creative thinking skills are not visible. From the findings that the researchers observed in the field, it turned out that many students obtained low or even below average learning outcomes. The KKM standard for class VII in Mathematics at SMP Negeri 4 Padang is 70.

One teacher at SMP Negeri 4 Padang stated that students get low learning outcomes because students do not understand the material presented in the *Geschool*. This is because the material presented in the *geschool* is only a summary of the material without a more detailed explanation. Not only that, other learning resources used in comparative material use textbooks and academic literacy. The material in the book is presented in a high language so that it is difficult for students to digest every sentence presented. he also explained that online learning during the Covid-19 pandemic using the *geschool* not been able to improve students' critical and creative thinking skills. Critical thinking skills do not come by themselves but need to be trained through learning (Friedrichsen, 2001).

Based on these problems, it is necessary to make efforts to improve students' critical thinking skills. The solution that can be done is to apply a model that is able to develop students' critical thinking skills. One learning model that involves all students in thinking activities is Problem Based Learning (BSNP, 2010). Problem Based Learning (PBL) is a learning model that is based on constructivism and accommodates the involvement of students in learning and is involved in solving contextual problems (Warsono, 2012).

The application of learning using the PBL model according to Gorghiu (2015), revealed that the application of the PBL model can improve students' critical thinking skills. The benefits of implementing PBL according to several studies are: (1) Galbert (2014), The application of the PBL learning model can improve students' critical thinking; (2) Ulger (2018), The

application of the PBL learning model can improve students' critical and creative thinking. Through this PBL learning model students can be active, creative, innovative in accordance with the objectives of implementing the 2013 curriculum.

Furthermore, an active, creative, and innovative learning module is needed so that it can arouse students' learning interest. But in reality in the field there is no media specifically designed to support the learning process so that it is more directed so that it can direct students to be more active, especially in learning mathematics. With this, an interesting E-Module is needed and can be used as a benchmark for teachers to see students' critical and creative thinking abilities. E-Module is a teaching material media in electronic form. This e-module is presented complete with interactive media such as video, audio, animation, and other interactive features that students can play and replay via smartphones, computers, laptops, and even tablets. This e-module is in accordance with the demands of the 21st century in the point 4.0 era, students are required to be proficient in using technology.

Not only that, in this E-Module an evaluation will also be presented in the form of questions related to the material presented in this E-Module. With an interesting and practical evaluation, students will be free to solve existing math problems. So that through this evaluation, students will be able to develop creativity and critical thinking patterns and encourage students to be more active in learning more about mathematics.

The E-Module is designed using a Problem Based Learning (PBL) based model. This is in line with research conducted by Santosa. AS, et al (2017) stated that the learning outcomes of students using the E-Module which had been developed in network subjects for class XII students of network and computer engineering using the Problem Based Learning (PBL) model were declared successful in being applied in that class. Another study conducted by Gijselaers (1996) shows that the application of Problem Based Learning (PBL) enables students to identify known and necessary information as well as strategies for solving problems. Based on this, the application of Problem Based Learning (PBL) can improve students' ability to solve problems so that the E-Module that the researcher will design can be used as an alternative to assist in an interesting learning process. Apart from being interesting, the Problem Based Learning (PBL) based E-Module in mathematics learning is expected to improve critical and creative thinking skills so that it becomes teaching material that is valid, practical, and effective to use.

II. METHODOLOGY

Type of research used is research *and development* (R&D). R&D is a process of developing educational tools that is carried out through a series of research using various stages, namely validity, practicality and effectiveness (Ali and Asrori, 2014). The development model used in this study is the plomp development model. Based on this cycle, Plomp divides the development stage into three stages, namely the*preliminary research*phase, the development*or prototyping phase*, and the*assessment phase*. These three stages will be explained in the development procedure. The product to be developed is an *e-module* based on *Problem Based Learning* to improve the mathematical critical and creative thinking skills of class VII students of junior high school. The instrument used is the validity, practicality and effectiveness of the instrument. Data collection techniques were questionnaires and documentation then data were analyzed qualitatively and quantitatively.

III. RESULTS AND DISCUSSION

3.1. Results

The results of this study are described based on the process and results of the *e-module* based on the *problem-based learning* to improve mathematical critical and creative thinking skills on the topic of comparative class VII junior high school semester 1 which are valid, practical, and effective.

The e-module designed in the early stages is called prototype 1. *The e-module* designed in prototype 1 is validated through*self-evaluation*and validation by experts or experts (*expert review*). At the *self-evaluation* researcher re-checked prototype 1 with a little help from colleagues from the same department. After conducting revisions to the *e-module* that had been evaluated at the *self-evaluation* , prototype 1 was produced. The results of the revision or *prototype* 1 were then consulted and discussed with experts who were competent in their fields.

Validation at the *expert review stage of the mathematical e-module* based on the *problem-based learning* was validated by 5 experts by discussing *the e-module* that had been designed. *e-module* was validated by 3 mathematics education lecturers, 1 educational technology lecturer and 1 language lecturer. The following describes the results of *e-module*e validation by

experts.validation process *e-module* model *problem-based learning* carried out in conjunction with lesson plans validation activities.the following, you can see the results of the validation of the *e-module* based on the *problem-based learning* in table 1.

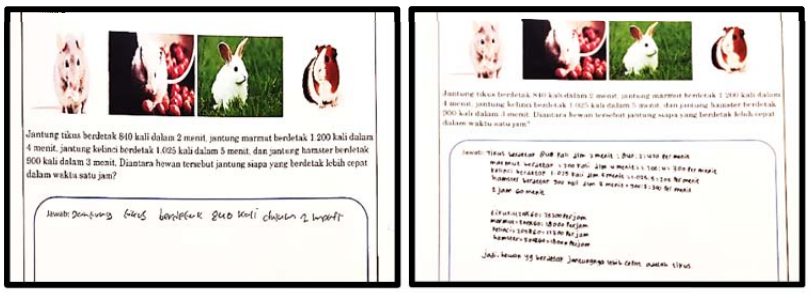
Table 1. Module Validation Results Using the Problem Based Learning Model

No	Aspek yang dinilai	Indeks validitas	Kategori
1	Presentation	3.57	Very Valid
2	Content eligibility	3.55	Very Valid
3	Language	4.00	Very Valid
4	Graphics	3.38	Valid
Average validity index		**3.62**	Very Valid

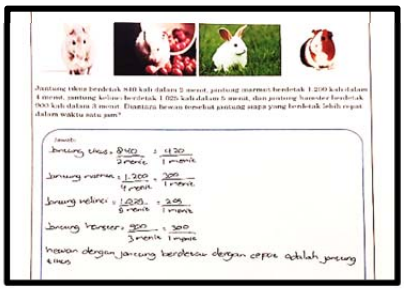
After the validation process was carried out through the *self-evaluation* stage and the *expert review* was completed, prototype 1 was repaired according to the validator's suggestion. The results of the revision on *prototype 1* are called *prototype 2.* Next, on *prototype* 2 a practicality test of the *e-module* model *problem based learning*

The practicality test on *prototype* 2 was carried out through 2 stages, namely the *one to one evaluation* stage and the *small group evaluation stage.* In the *one-to-one evaluation* , 3 class VII students of SMPN 4 Padang were selected based on the results of previous mathematics studies with different levels of ability. Before students work on *the e-module,* students are asked to first observe the start page and understand the instructions for using *-module* e *problem-based learning* Based on the assessment of the initial page, the three students liked the design and understood the instructions for using the *e-module,* and were happy the first time they tried using learning media other than books and printed modules.

After students understand how to use the *e-module,* students begin to study *the e-module.* In this *one to one evaluation* , students carry out several activities. *Activity 1,* students are asked to observe and understand the problems provided. It can be seen that during the learning process, students are still confused about the stages of the *problem-based learning* contained in *the e-module* , so they still need guidance from researchers to better understand the intent of each stage of learning. Furthermore, in activity 1 it can be seen that students with low abilities still have difficulty analyzing problems at the problem orientation stage, so they do not complete them according to the order in which the questions have been resolved. Students with moderate abilities have solved the problems according to what has been taught, but there are still a few errors during the comparison process. *Activity 2,* the results of observations on the e-module activity 2 are that low-ability students are getting used to using e-modules in the learning process, but still have doubts when solving problems at the learning orientation stage, so they need guidance from educators. This means that the critical and creative thinking skills of low-ability students are still lacking. The following is an example of student answers at the problem orientation stage, which can be seen in the following figure.



Low Ability Learners **Moderate Ability Learners**



High Ability Learners

Figure 1. Student Answers at the Problem Orientation Stage Activity 2

Activity 3, still related to the *e-module* in the previous activity, so that students are able to solve problems at the orientation stage and organize problems by students. Based on the results of observations in activity 3 for low-ability students there are still a few difficulties in solving existing problems, so guidance is still carried out by researchers. *Activity 4,* the results of observations on this are the three students who have different abilities have understood and solved the problem properly and correctly. This is because the material for activity 4 is not much different from activity 3, so that in activity 4 students' mathematical creative and critical thinking skills have increased. *Activity 5.*The observations obtained were that students with high, medium and low abilities were able to solve problems at each stage of *problem-based learning,* so that it could be seen that there was an increase in students' mathematical critical and creative thinking abilities. *activity 6,* in this activity is the continuation of material from activity 5 regarding comparisons of value, while at meeting 6 students will study material on comparisons of value. The results of observations on *the e-module* activity 6 are that students with high, medium and low abilities have been able to solve problems in each lesson properly and correctly, but there is still some doubt because the way of solving them is slightly different from the equivalent comparison material. So that the ability to think critically is still slightly decreased but the ability to think creatively has increased in solving existing problems.

At the end of the learning process, the researcher provided information to students that *e-module* 6 was the *e-module* in comparative material. After students complete *e-module* learning . So at the end of the activity the students were interviewed in turn. The results of interviews with students at the *one to one evaluation* can be seen in the following table 2.

Table 2. Results of Interviews with Students in the One to One Stage

No	Aspects Assessment	Student		
		High Ability	**Moderate Ability**	**Low Ability**
1	Presentation of e-module based on Problem based learning model	1. The instructions for using the e-module are very clear 2. The instructions for using the e-module are complete and understandable 3. The pages, covers, and contents of the e-module are very interesting	1. The instructions on the e-module are clear 2. Instructions for using the e-module are complete and easy to understand 3. The pages, covers and contents of the e-module are attractive	1. The instructions on the e-module are quite clear 2. The instructions on the e-module are clear 3. Interesting enough

2	Ease of use of the module	4. The E-Module used is easy to use. 5. Just read 1-3 times 6. The stages of learning in the e-module make it very easy to understand the material 7. Questions on the e-module can provoke critical and creative thinking.	4. Fairly easy to use 5. As much as 2-3 times reading. 6. This E-Module can make it easier to understand the material. 7. The questions on the e-module are quite difficult but can provoke an increase in mathematical abilities	4. Pretty easy to use 5. 2-4 times reading. 6. This E-Module is a bit difficult to understand. 7. The problem is quite difficult.
3	Time allocation accuracy and module legibility	8. According to the time given 9. Writing is clear and legible 10. The use of language used is very good and easy to understand	8. The time given is felt to be less 9. Writing is clear and legible 10. The use of language in the e-module is easy to understand	8. There is very little time 9. Clear and legible 10. The use of language is easy to understand

Overall, the results of observations at the *one to one evaluation* show that *the e-module* is easy to understand and work on, although there are still slight improvements. This is in accordance with research conducted by previous researchers that a teaching material is said to be practical if it can be understood and used easily by students.

In the *small group evaluation* researcher acts as an educator by using learning stages designed in lesson plans based on *problem based learning*. During the activities at this stage the researcher is assisted by educators as observers. The observer served as an observer of the implementation of learning according to the *problem based learning*. Based on the observations that the researchers saw, at this fifth meeting the students were active in learning. When working on the e-module, group 1 and group 2 seemed able to understand and complete the stages in the e-module. Furthermore, the researcher asked students to solve problems independently at the incubation stage and enter memory, at this stage an increase in students' mathematical critical and creative thinking abilities was already visible. Then at the stage of organizing students to study, students in groups work on problems on LKPD. Based on the results of the work of the two groups, it can be seen at the stage of developing and presenting the results that both group 1 and group 2 have been able to complete the LKPD.

In the *small group evaluation* , each observer meeting provides an assessment of the implementation of *the e-module* based on the *Problem Based Learning model.* Recapitulation of the average observer assessment of the implementation of *the e-module* at the small group trial stage can be seen in the following table 3.

Table 3. Recapitulation of the Average Observation Results of *E-module* Model *Problem Based Learning* (*Small Group*)

No	Rated aspect	Score Obtained (R)	Practicality Value (%)	Category
1	The instructions for using the e-module do not require much additional explanation	3,67	91,75	Very Practical
2	The first problem gives stimulation to students	3,51	87,75	Very Practical
3	Instructions or work steps do not require much explanation from educators	3,67	91,75	Very Practical
4	Questions and e-module commands direct students clearly in solving problems	3,5	87,5	Very Practical
5	Questions and instructions in the e-module direct students clearly to collect data individually	3,33	83,25	Practical
6	The material is in accordance with the level of thinking of students	3,17	79,25	Practical
7	The language used is communicative	3,17	79,25	Practical
8	The use of problem-based learning-based e-modules makes students more active	3,33	83,25	Practical
9	E-module activities help students at the problem orientation stage	3,33	83,25	Practical
10	E-module activities help students at the stage of organizing students	3,5	87,5	Very Practical
11	E-module activities help students at the stage of guiding an investigation	3,5	87,5	Very Practical
12	E-module activities help students at the stage of developing and presenting results	3,4	85	Very Practical
13	E-module activities help students at the stage of analyzing and evaluating problems	3,33	83,25	Practical
14	E-module activities help students when drawing conclusions	3,4	85	Very Practical
15	E-module activities can help students understand problems	3,51	87,75	Very Practical
16	E-module activities can help students solve problems	3,67	91,75	Very Practical
17	Activities in the e-module can assist in solving problems based on a plan	3,67	91,75	Very Practical
18	The material presented in the e-module is according to the 2013 curriculum	3,33	83,25	Practical
19	E-module can be used as a substitute for other learning resources.	3,33	83,25	Practical
20	E-module can be used as a variation in the use of learning resources	3,67	91,75	Very Practical
Average		3,45	86,24	Very Practical

Based on the table above it can be seen that the practicality *of the e-module* for each aspect is "Practical" and "Very Practical". Overall the practicality value of the *e-module* is 86.24 in the "Very Practical" category. So it can be concluded that *e-modules* based *problem-based learning* already practical at the *small group evaluation*.

Next, at this stage a student response questionnaire was also given which scored 84.83% with the "Very Practical" criteria. Based on the *e-module* filled out by educators and students, *problem-based learning* are stated to be very practical.

Furthermore, at this stage an effectiveness test is also carried out which aims to see the critical and creative thinking abilities of students who are members of small groups. The results of tests of mathematical critical and creative thinking skills for each student indicator can be seen in the following table 4.

Table 1. The results of Small group mathematical critical thinking test results

Nama	Indikator			Velue (%)	Explanation
	Focus	Reason	Inference		
RRA	100	93,75	93,75	95,83	Very Critical
VA	100	93,75	83,7	92,48	Very Critical
CPS	93,75	81,25	81,25	85,42	Very Critical
GAA	93,75	87,5	93,75	91,67	Very Critical
CEG	100	87,5	87,5	91,67	Very Critical
ZJT	87,5	81,25	81,25	83,33	Very Critical
Average	**95,83**	**87,50**	**86,87**	**90,07**	Very Critical

Table 2. The results of Small group mathematical creative thinking test results

Nama	Indikator				Value (%)	Explanation
	Fluency	Flaxibility	Original	Elaborasi		
RRA	100	95	100	100	98,75	Very Creative
VA	95	95	90	90	92,5	Very Creative
CPS	85	85	90	95	88,75	Very Creative
GAA	100	100	95	90	96,25	Very Creative
CEG	95	95	95	95	95	Very Creative
ZJT	80	80	90	90	85	Very Creative
Average	**92,5**	**91,7**	**93,3**	**93,3**	**92,7**	**Very Creative**

Based on the table above, it can be seen that the value of the effectiveness test at the *small group* obtained a result of 90.07 for mathematical critical thinking skills, obtained a result of 92.7 for students' mathematical creative thinking abilities, if referring to the effectiveness criteria of a product (Table 22) it can be it can be seen that the learning tools developed at the *small group evaluation* categorized as "Very Effective".

3.2. Discussion

Based on the facts found at SMPN 4 Padang, it was found that the students' mathematical critical and creative thinking skills still needed to be improved. Referring to the learning objectives in the 2013 curriculum, students are required to have the

ability to think mathematically, including critical thinking and creative thinking. The use of learning e-modules greatly influences the results obtained by students, this is in line with research conducted by Ramadanti et al., (2021) which states that the use of Problem Based Learning-based mathematics e-modules for junior high school level students can affect the level of completeness of the students' mathematics learning outcomes.

One of the efforts that can be made to overcome this problem is to apply a mathematical e-module based on problem-based learning models to improve students' mathematical critical and creative thinking skills. The design of the mathematical e-module based on the problem-based learning model went through several stages in accordance with the Plomp development model, namely the preliminary research stage, the development or prototyping phase, and the assessment phase. in order to obtain a mathematical e-module based on a valid and practical problem-based learning model. As well as effective for increasing the ability to think critically and creatively mathematically. The following is a description of each aspect.

3.3. Validity

Validity comes from the word valid which means according to the way it should be, meaning that a device is said to be valid if all the *e-module* meet the requirements. The validity *of the e-module* based on the *problem based learning* assessed based on four aspects, namely, (1) the content aspect is assessed from the suitability of the product produced with the material, and activities in the *problem based learning model,* (2) the presentation aspect is assessed from the suitability of the product produced with the composition the product should be, (3) linguistic aspects are assessed based on the appropriateness of the language used in the resulting product with the user's level of understanding, and assessed from the suitability of punctuation, correctness in typing, and writing in accordance with PUEBI (General Guidelines for Indonesian Spelling), and (4) graphical aspects are assessed based on the appearance and design of the products produced.

Based on the results of the assessment analysis carried out by 5 experts consisting of 3 mathematics education lecturers, 1 educational technology lecturer, and 1 Indonesian language lecturer, it was found that the product produced, namely *e-module* models, *problem-based learning* was valid for all aspects of assessment. The average value of validity for *e-modules* models *problem based learning* is 3.62 with the criteria of "Very Valid". Based on the validator's assessment of *e* model- *problem-based learning* it can be concluded that *e-module* is valid.

This is supported by the results of Nurlina's research (2021), where the average *e-module* based on the *problem-based learning* by material experts was 3.36 with the "Valid" criterion, and media experts obtained an average of 3.31 with the category "Valid", so that *e-modules* based on *Problem Based Learning* are declared feasible for testing. In addition, research conducted by Hidayatulloh (2020), obtained an average of 85.65% from material experts and 82% from media experts with the criteria of "Very Valid".

3.4. Practicality

Practicality relates to *of e-module* by students and educators. An *e-module* is said to be practical, if students or educators can use *the e-module* to carry out learning and have no difficulties, both in terms of presenting the material and its use.

Based on the learning process, it was found that students could find concepts or understand each concept from the material being studied. Implementation *e-modules* based *problem-based learning* in trials can be seen that the time provided is sufficient to carry out learning activities, and students also have no difficulty solving problems in *the e-modules* given, although there are some students who feel the time given lacking and experiencing difficulties in completing *the e-module*, but with the group learning method it can help students discuss and exchange ideas to solve them.

This refers to the recapitulation of the questionnaire responses of educators and students showing that the learning e-module developed is interesting and easy to use, especially because students have never previously learned to use an e-module like this. The practicality assessment of the e-module based on the problem-based learning model to improve students' mathematical critical and creative thinking skills is carried out in stages according to the stages of learning. Starting from asking for the response of 6 students at the small group stage to provide an assessment of the e-module and obtain an average practicality of 84.83% with the "Very Practical" criterion. Then the e-module practicality assessment was continued by asking for responses from 32 students at the field test stage obtaining an average practicality result of 88.78% with the "Very Practical" criterion.

Furthermore, the educator's response questionnaire to the e-module obtained an average of 90.5% with the "Very Practical" criteria.

3.5. Effectiveness

Effectiveness according to the Indonesian Dictionary comes from the word effective which means there is an effect, influence and the impression of giving effective results. Effectiveness is obtained from the results of student analysis at each meeting, student response questionnaires, and tests of students' mathematical critical thinking abilities. The device can be said to be effective if students are successful in the learning process and there is consistency between the curriculum, learning experience, and the achievement of the learning process (Purboningsih, 2015: 469).

The effectiveness test in this study was conducted to see the results of the use of problem based learning e-module models in the learning process, namely in increasing students' mathematical critical and creative thinking skills after the learning process was carried out. Relevant research conducted by Kusumasari et al., (2022: 199) states that the problem-based learning model gives the results of implementing e-modules showing a positive response and increasing understanding of the material studied in the good category.

The final test of mathematical critical and creative thinking skills is a test item used to determine student learning outcomes after the learning process. The development of teaching materials in the form of e-modules based on the problem-based learning model in this study is said to be effective if the average final test results for students' mathematical creative and critical thinking abilities achieve a grade of . Of the 6 students who took the effectiveness test on the problem-based learning model-based e-module at the small group evaluation stage, it was found that the six students obtained the criteria of "Very Critical" on mathematical critical thinking skills and obtained the criteria of "Very Creative" on creative thinking abilities. mathematically, and if it is based on the e-module effectiveness criteria at the small group stage, a value of 90.07% (Critical thinking ability) and 92.7% (creative thinking ability) is included in the "Very Practical" criteria.

Furthermore, at the field test stage an effectiveness test was also carried out on 32 students who had carried out learning with the problem based learning e-module model, it was concluded that the use of the mathematics e-module was effective, by recapitulating the average final ability test results Mathematical critical thinking as a whole obtained a result of 84.8% with the criteria of "very high" and the average final test result for the ability to think creatively mathematically as a whole obtained a result of 87.7% with the criteria of "Creative".

This is in line with research conducted by Ramadanti et al., (2021) which states that students have achieved individual competence or classical PBL-based mathematics e-module which is based on a completeness percentage of 85% in data presentation material that meets the "effective" category. So, if seen based on the results above and matched with the criteria for categorizing the effectiveness of the e-module, it can be said that the e-module based on the problem-based learning model to improve students' critical and creative mathematical thinking skills has been effective.

IV. CONCLUSION

Based on the research results, it can be concluded that the characteristics of the e-module based on the problem based learning model developed for class VII SMP for KD comparison are valid, practical, and effective. Based on data analysis and discussion, it can be concluded that the results of the development are as follows.

1. The results of the validation from the validators show that the e-module is based on the problem-based learning model developed with valid criteria because it meets the validity characteristics both in terms of content, presentation, language, and graphics. In terms of content, the e-module is based on the problem-based learning model in accordance with the 2013 curriculum, scientific activities and subject matter. In the aspect of presentation, the e-module is based on the problem-based learning model in accordance with the rules for preparing teaching materials according to Permendikbud No. 22 of 2016, the systematization of the learning approach steps, and the completeness of the components in the e-module. In the linguistic aspect, the e-module is based on the problem-based learning model in accordance with the use of language with good and correct rules or in accordance with the General Indonesian Spelling Guidelines (PUEBI). In the graphical aspect, this e-module is correct in terms of cover design, font type and size, image layout, image relevance, color use, and templates.

2. The characteristics of the e-module based on the problem-based learning model developed for comparison material for class VII junior high school that is practical is that it meets practical criteria both from the aspect of implementation, convenience and time required.
3. The problem-based learning model-based e-module at the trial stage is included in the effective category. It can be seen in the impact and influence of the use of e-modules which can improve students' critical and creative mathematical thinking skills. At the time of implementation students look active and very enthusiastic in learning. The test results show that the average test of students' mathematical critical thinking skills after being tested is 84.8% in the very critical category, with the criteria of students' mathematical critical thinking abilities in each indicator being 91.4% for focus indicators, 84.6% for the reason indicator, and 78.5% for the inference indicator. While the average test results for students' mathematical creative thinking abilities after being tested were 87.7% in the very creative category, with the criteria for each indicator being 87.3% for the fluency indicator , 87.2% for the flexibility indicator, 88.8% for the elaboration indicator, and 87.7% for the originality indicator. This shows that the questions given can be well understood and illustrates that e-modules based on problem-based learning models can assist students in finding comparative concepts. Therefore it can be said that the developed e-module can be categorized in the effective category.

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