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Development of Desmos Electronic Students' Activities Sheet (E-LKPD) based on the Problem Based Learning to Improve Students' Mathematical Critical Thinking Skills

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A B S T R A C T

The purpose of this study was to improve students' mathematical critical thinking skills using the developed Desmos Electronic Student Worksheet (E-LKPD) based on Problem Based Learning, student responses after using the Desmos E-LKPD, and the practicality of Desmos-based E-LKPD Problem-Based Learning was developed. From the research results it is known that: (1) Based on the aspect of critical thinking skills, the aspect of interpretation increases by 9%, the aspect of analysis increases by 18%, the aspect of evaluation increases by 42%, and the aspect of inference increases by 48%. (2) The results of the students' answers are included in the good category with a proportion of 80.31%. (3) The Problem Based Learning-based E-LKPD Desmos that has been developed has met the effective criteria in terms of the assessment of media experts, material experts, and user experts in the valid category, classical learning completeness has reached 80.65%, and Gain results of 0 .5 with medium category. The practicality test results get 92.18% in the very practical category.

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INTRODUCTION

Developments in information and communication technology are currently growing rapidly. The use of technology in the world of education is also increasingly being intensified. Utilization of information technology in the world of education, among others, can help in the learning process. For example, teaching materials can be displayed in various formats and forms that are more attractive and interactive so that students are more interested and motivated to participate in learning. The presence of technology can also assist in the presentation of data/information better, facilitate the interpretation of data and in obtaining information. And can be used by teachers in preparing lesson plans.

Indrianto (in Akhyak, 2021:7) stated that this was related to the program "Merdeka Belajar Kampus Merdeka" which was initiated by Nadiem Makarim as the Minister of Education and Culture. School digitization is a necessity and a must as a solution to the challenges and developments of the times. Thus, the use of technology is something that cannot be avoided in this day and age. Digitizing schools will encourage collaboration between teachers and students. Not only that, learning becomes more interactive because students are involved in the activities of the teaching and learning process. Students can also access material and exchange information quickly. So, teachers must continue to improve their competence. Teachers not only play a role in transferring knowledge but also must be able to facilitate the needs and improve the competence of students optimally so that they are able to face future challenges. Teachers are required to be able to become a liaison for learning resources or a absorption linker which requires teachers to master relevant learning resources to be accessed by students anytime and anywhere.

However, teachers still experience problems in utilizing technology in learning. Constraints experienced by teachers in utilizing technology in learning include the lack of teacher knowledge about IT, lack of IT facilities available in schools, abnormal electric currents in schools, the internet cannot reach all classes, and there is no obligation on the part of the school so that teachers who teaching must use IT (Sahelatua et al, 2018: 131).

According Listyaningsih et al. (2020) Critical thinking is one of the important aspects that can be formed through education to preapare Indonesia's golden generation in 2045. According Diharjo et al. (2017) critical thinking is an important thing that must be possessed in building student knowledge. critical thinking skills will stimulate students' cognitive reasoning in acquiring knowledge. Students' critical thinking is needed, because during the learning process students develop ideas for the problems contained in learning.

Based on preliminary research at SMP Negeri 1 Babalan by being given a test to diagnose students' critical thinking skills in class VIII-4, the results obtained for interpretation indicators were in the high category with a percentage of 83,46%, analysis indicators were in the medium category with a percentage of 77,41%, while the evaluation indicators are in the low category

with a percentage of 57,25%, and the inference indicators are in the very low category with a percentage of 46,77%.

Zulfah (2017:3) one of the determinants of the success of the learning process and success in achieving the objectives of learning mathematics is learning tools. Learning tools are a set of tools or components used in the learning process consisting of a syllabus, lesson plans (RPP), teaching materials, and learning outcomes tests. One of the printed teaching materials used in the learning process in schools is the Student Worksheet or abbreviated as LKPD.

According to Putri (2018) critical thinking can be improved by using a variety of learning models and teachers often provide problem-based questions. Sofyan, H and Komariah, K. (2016: 263) Problem-based learning (PBL) is an active learning strategy that is highly recommended in the implementation of the 2013 Curriculum. This learning strategy aims to improve students to learn independently, using real-world problems as a context for students to learn with critical thinking and life problem-solving skills. So that LKPD with problems based on *Problem Based Learning* (PBL) is very appropriate to improve students' critical thinking skills

According Utari et al. (2019) suggest that one of the obstacles faced by students when learning mathematics is an abstract object. In addition, to make it easier for students to understand abstract mathematical objects, teachers need a media that can visualize abstract objects into other, more concrete representations for students.

Incorporating technology into the LKPD, it can overcome students' problems in visualizing abstract mathematical objects. Therefore, teachers need to develop teaching materials that utilize technology such as Electronic Student Worksheets (E-LKPD) (Rahayu, et all, 2021).

Based on the description above, the wants to do research that will focus on produce Electronic Student Worksheets (E-LKPD) based on Desmos Problem Based Learning to improve proper students' critical thinking skills, to find out student responses to the Electronic Student Worksheet (E-LKPD) based on Problem Based Learning which was developed on Cartesian Coordinates material in class VIII-4 SMP Negeri 1 Babalan, and To find out the effectiveness and practicality of the Desmos Electronic Student Worksheet (E-LKPD) based on Problem Based Learning in improve students' critical thinking skills. The researcher wishes that this research will be contribute to developing knowledge and enriching research results regarding the development of previous E-LKPD.

THEORETICAL REVIEW

The Student Worksheet (LKPD) is a student guide used to carry out investigations or problem solving activities. LKPD can be in the form of a guide for the exercise of developing cognitive aspects or a guide for developing all aspects of learning in the form of an experimental or demonstration guide. Prastowo (2014) said LKPD is a printed material in the form of sheets of paper containing material, summaries, and instructions for implementing learning tasks that must be done by students, which refers to the basic competencies that must be achieved.

According to Ibrahim and Nur (2010); and Butcher (2006) (in Syamsidah, 2018) the Problem Based Learning (PBL) model is a learning model in which the target student is involved in trying to solve problems with several stages of the scientific method so that students are expected to able to learn knowledge related to the problem and at the same time students are expected to have skills in solving problems. PBL will be a learning approach that seeks to apply problems that occur in the real world, as a context for students to practice critical thinking and gain skills to solve problems.

The ability to think critically is one of the life skills that needs to be learned and developed. Glaser (in Puspita and Dewi, 2021) explains critical thinking as an skills to think deeply about problems and apply them in methods of examination and logical reasoning. Sukmadinata (2012) critical thinking is a skill in reasoning regularly. It means having to think systematically in assessing, solving problems, making decisions, and expressing beliefs with clear evidence. Learning to think in a critical analytical and evaluative way means using mental processes such as attention, categorization, selection, and judgment. Cotrrel (in Minarni et al, 2022) states that critical thinking gives humans the tools to use criticism and doubt constructively so that they can analyze what is in front of them. This helps people to make better and more informed decisions about wheter something is likely to be right, effective or productive.

Ennis in Jayadipura (2014) details the indicators of critical thinking skills that can be derived from students' critical activities as follows: (1) Looking for clear statements from each statement, (2) Looking for reasons, (3) Trying to find out information well, (4) Use sources that have credibility and mention them; (5) Looking for alternatives, (6) Having an open mind and attitude; (7) Take a position when there is sufficient evidence to do something; (8) Seek explanations as much as possible if possible, (9) Be systematic and orderly with the parts of the whole problem.

Meanwhile, Facione (in Putri, 2018: 797) explains, critical thinking indicators include 4 aspects, namely: 1) Interpretation is understanding the problem indicated by writing known or asked questions correctly; 2) Analysis is identifying the relationships between the statements, questions, and concepts given in the questions shown by making the mathematical model correctly and giving the right explanation, 3) Evaluation is using the right strategy in solving the problem. , complete and correct in performing calculations; 4) Inference is using the right strategy in solving problems, complete and correct in doing calculations. From the several indicators above, the critical thinking indicators in this research are: Interpretation, Analysis, Evaluation and Inference.

METHODOLOGY

This research is a development research (R&D). This development research was carried out to produce a Desmos Electronic Student Worksheet (E-LKPD) product based on Problem Based Learning to improve students' critical thinking skills. This research was conducted at the SMP Negeri 1 Babalan, The subjects in this study were 31 students of class VIII-4 of the SMP Negeri 1

Babalan for the academic year 2022/2023. While the object in this study is the Desmos Electronic Student Worksheet (E-LKPD) based on Problem Based Learning on Cartesian coordinates material. This study refers to the 4-D Thiagarajan model which consists of four main stages namely: define stage, design stage, development stage, and disseminate stage. However, in the disseminate stage, it was only carried out in small groups, namely teachers and students of class VIII-4 SMP Negeri 1 Babalan due to the limited time and ability of researchers.

In this development research using data collection techniques are observation, interviews, validation, questionnaires, and tests (pre-test and post-test). Technical data analysis aims to interpret the research results obtained. The data obtained in this study are qualitative and quantitative data. Quantitative data in the form of assessment scores from validators, student response questionnaires, and tests of students' critical thinking skills. As for qualitative data in the form of responses given by validators, teachers, and students about the developed Desmos E-LKPD.

To find out the score of the validation results that have been given by media experts, material experts, user experts validation the following formula is used: (Sinaga, 2007).

a. Recapitulating the data on the validity of learning devices into a table which includes: aspects (A_i), indicators (I_i), and the value of each expert (v_j).
b. Determine the average value from the expert for each indicator with the formula

$$I_i = \frac{\sum_{j=1}^{n} v\ i\ j}{n}$$

c. Determine the average value for each aspect with the formula

$$A_i = \frac{\sum_{j=1}^{m} l\ i\ j}{n}$$

Information:
A_i is the average value for the i-th aspect,
$l\ i\ j$ is the average for the i-th aspect of the j-th indicator,
n is the total of indicators in the i-th aspect

d. Determine the value of V_a or the total mean value of the average value for all aspects with formula:

$$V_a = \frac{\sum_{j=1}^{n} v\ i\ j}{n}$$

Information:
V_a is the total mean value for all aspect,
A_i is the average value for the i-th aspect,
n is the total of aspects

Furthermore, the value of V_a or this total value is referred to the interval of validity of students worksheet based on problem-based learning capital which refers to Hobri which can seen in the following table 1:

Table 1. Validation Result Criteria

V_a (total average)	Category
$1 \leq V_a < 2$	Invalid
$2 \leq V_a < 3$	Less Valid
$3 \leq V_a < 4$	Quite Valid
$4 \leq V_a < 5$	Valid
$V_a = 5$	Very Valid

Data analysis was obtained from the results of students response questionnaire, practicality questionnaire, and students' critical thinking ability test which was used to measure the quality of the Desmos E-LKPD. The formula used for data analysis are:

$$P = \frac{n}{N} \times 100\%$$

Description :

P = rating percentage (%)

n = total score obtained

N = the maximum number of scores

After that the data is converted into descriptive qualitative data using the following assessment criteria:

Table 2. Criteria for Student Response Questionnaire Results (Akbar, 2013)

Percentage (%)	Category	Decision
81,25 < X ≤ 100	Very good	Learning media is very good, does not require revision, the media is ready to use
62,5 < X ≤ 81,25	Good	Good learning media, requires small scale revision
43,75 < X ≤ 62,5	Enough	Learning media is quite good, needs medium scale revision
25,33 < X ≤ 43,75	Not feasible	Learning media is not good, requires revision on a large scale

Table 3. Criteria for Practicality Test Sheet Results (Adaptation of Riduwan in Wahyuni, A. S and Miterianifa, 2019: 82)

Percentage (%)	Category
80 < X ≤ 100	Very Practical
60 < X ≤ 80	Practical
40 < X ≤ 60	Quite Practical
20 < X ≤ 40	Less Practical
0 < X ≤ 20	Not Practical

Table 4. Criteria for Students' Critical Thinking Ability Test Score Criteria (Joko in Putri A, 2018: 789)

Percentage (%)	Category
89 < X ≤ 100	Very high
78 < X ≤ 89	High
64 < X ≤ 78	Currently
55 < X ≤ 64	Low
0 < X ≤ 55	Very low

The data obtained from the critical thinking ability test of students were analyzed to determine the improvement of students' critical thinking abilities, so that the effectiveness of the Desmos E-LKPD which was developed in improve students' critical thinking skills could be seen. The analysis was carried out by comparing the scores of the pretest and posttest results. The analysis uses the N-gain formula from Hake (1999) as follows:

$$N - gain = \frac{posttest\ score - pretest\ score}{score\ ideal - pretest\ score}$$

With the following index criteria :

Table 5. Normalized Gain Score Criteria (Hake, 1999)

Percentage	Interpretation
$g > 0{,}7$	High
$0{,}3 < g \leq 0{,}7$	Currently
$g \leq 0{,}3$	Low

RESULTS

Media expert validation was carried out by giving a questionnaire to lecturer in Computer Science Unimed as media experts. There are three aspects assessed by media experts, namely software engineering, visuals, and interactivity. The results of media expert validation from all aspects assessed are contained in the table 6.

Table 6. Media Expert Validation Result

No	Aspect	Average Each Aspect	Criteria
1	Software Engineering	4,75	Valid
2	Visual	4,5	Valid
3	Interactivity	5	Very Valid
Total Average V_a		**4, 75**	**Valid**

From the table above, the average validation of E-LKPD is 4.75. Based on the criteria for the level of validity, it can be concluded that the developed E-LKPD meets the criteria for validity with a valid category.

Material expert validation was carried out by giving questionnaires to Unimed Mathematics Education lecturers as material experts. There are four aspects assessed by material experts, namely aspects of the scope of Cartesian coordinate material, aspects of presenting Cartesian coordinate problems in E-LKPD, Language, and Problem Based Learning-based E-LKPD Aspects. The results of material expert validation from all assessed aspects are contained in the table 7.

Table 7. Material Expert Validation Result

No	Aspect	Average Each Aspect	Criteria
1	Cartesian Coordinate Coverage	4,87	Valid
2	Presentation of the Cartesian coordinate problem in the E-LKPD	4,6	Valid
3	Language	4,83	Valid
4	Aspects of E-LKPD based on Problem-Based Learning	5	Very Valid
Total Average V_a		**4, 82**	**Valid**

From the table above, the average validation of E-LKPD is 4.82. Based on the criteria for the level of validity, it can be concluded that the developed E-LKPD meets the criteria for validity with a valid category.

User expert validation was carried out by giving questionnaires to expert users. Expert users in this study were teachers of Mathematics at SMP N 1 Babalan. The validation results aim to obtain information that will be used to improve the quality of the developed E-LKPD. There are three aspects used for the assessment. The results of the assessment of each aspect can be seen in the table 8.

Table 8. User Expert Validation Results

No	Aspect	Average Each Aspect	Criteria
1	Contents	4.87	Valid
2	Presentation	4.62	Valid
3	Overall Functions of Desmos E-LKPD	5	Valid
Total Average V_a		**4.83**	**Valid**

Based on the results of the validation of the average overall aspects obtained 4,83. Based on the criteria for the level of validity, it can be concluded that the critical thinking test developed meets the criteria for validity with a valid category. The validator says that the E-LKPD can be used. However, the suggestions submitted by the validator are taken into consideration in improving the E-LKPD.

In this research, the level of mastery of students was reviewed using a critical thinking ability test. The critical thinking ability test is given consists of a pre-test and a post-test. The pre-test was given before learning using the Desmos E-LKPD, while the post-test was given after the lesson using the Desmos E-LKPD was completed. Giving pre-test and post-tests aims to determine the increase in critical thinking skills obtained by students after learning using E-LKPD Desmos based on problem-based learning. Comparison of pre-test and post-test results can be seen in the picture.

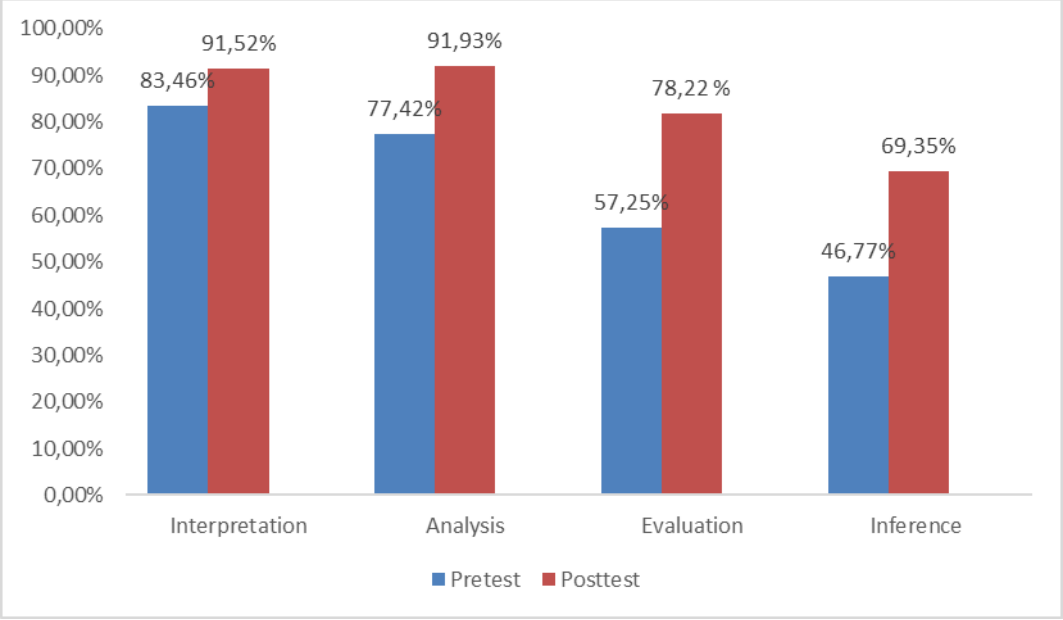

Figure 1. Critical Thinking Ability Mastery Level of Pre-Test and Post-Tes

From the figure 1, it can be seen that there is an increase in the results of the pre-test with the results of the post-test. Indicator interpretation on the pre-

test got 83,46% results then increased to 91,52% on the post-test results, indicator analysis got 77,42% results on the pre-test then on the post-test increased to 91,93%, indicator evaluation on the pre-test got 57,52% results then increased in the post-test results to 81,85%, the inference indicator got 46,77% results in the pre-test results then increased to 69,35% in the post-test results. To see more clearly the increase in the results of the pre-test and post-test for all aspects, see the following table 9.

Table 9. The Increasement of Critical Thinking Skills of Every Aspects

Aspect	Pre-test	Post-test	Enhancement	Percentage
Interpretation	207	227	20	9%
Analysis	192	228	36	18%
Evaluation	142	203	61	42%
Inference	116	172	56	48%

When viewed from the results of the pre-test and post-test of each indicator in the table, it can be seen that the interpretation aspect increased by 9%, the analysis aspect increased by 18%, the evaluation aspect increased by 42%, and the inference aspect increased by 48%.

Furthermore, the results of classical mastery of students' critical thinking skills can be seen in the table 10.

Table 10. Classical Mastery of Students' Critical Thinking Skills

Information	Pre-test		Post-test	
	Total Students	Percentage	Total Students	Percentage
Pass	17	54,84%	25	80,65%
Not Pass	14	45,16%	6	19,35%
Total	31	100%	31	100%

Based on the table above, it can be seen that the classical completeness of the student's critical thinking ability test in the pre-test was 54,84% and the post-test was 80,65%.

The improvement of students' critical thinking skills will be seen through the N-Gain test from the results of the pre-test and post-test scores. The N-Gain results can be seen in Appendix 18. The results of the N-Gain calculation can be seen in the following table 11:

Table 11. Score Gain

Score Gain	Interpretation	Total Students	Percentage
$g > 0,7$	High	7	22,58%
$0,3 < g \leq 0,7$	Currently	14	45,16%
$g \leq 0,3$	Low	8	25,80%

Based on the table, it can be seen that 7 students got N-Gain scores in the gain range > 0.7 which experienced an increase in the "High" category, there were 14 students who got N-Gain scores in the range $0{,}3 < g \leq 0{,}7$that experienced an increase in the "Medium" category, and there are 8 students who get an N-Gain score in the range $g \leq 0{,}3$that has increased in the "Low" category. So, the average obtained in the field trial is 0.5 with the "Medium" category.

The student response questionnaire was used to determine the student's response to the Desmos E-LKPD that had been developed. The results of student responses on the contents aspect are 70.43% in the good category, in the media aspect it is 86.63% in the very good category, and the Desmos E-LKPD functions aspect is 83.87% in the very good category. So the total percentage of all aspects is 80.31% with good category.

The practitioner who carried out the practicality test was a mathematics teacher at SMP N 1 Babalan who saw the process of using the E-LKPD in the classroom. Based on the practicality test results, the effectiveness aspect gets a percentage of 100% in the very practical category, the efficiency aspect gets a percentage of 87.5% in the very practical category, the creativity aspect gets a 100% percent in the very practical category, and the interactive aspect gets a percentage of 81.25% with a very practical category. So that the total percentage of all aspects got 92.18% results which can be concluded that the developed E-LKPD is in the "Very Practical" category.

DISCUSSION

In the initial study a test was conducted to diagnose students' critical thinking skills. The questions on the test are material that they have previously studied by their mathematics teacher. The results of this test are used as a pre-test which will be compared with the results of the posttest which will be given after learning using the E-LKPD is finished.

Before the trial stage is carried out, a limited trial stage is carried out first. This is done to find out whether the E-LKPD can operate properly. In the limited trial there were problems with the slow loading process. This is because the size of the image/video is too large, so the size of the image/video must be reduced. The E-LKPD application is carried out via a smartphone. Students open the E-LKPD via the link provided in the Whatsapp group. An email/google account is required to be able to login to the Desmos website. There are some students who forget their passwords and emails, so it is recommended to enter using chrome compared to other browsers because chrome is connected to a Google account. The opening part and activity I in E-LKPD are carried out on the same day, then activity II is carried out the next day together with a posttest. The students were directed to answer the problems in the E-LKPD then the results of student answers were displayed using the infocus and discussed together.

The results of the pretest and posttest can be compared as follows: In the Interpretation aspect the pretest results get 83.47% in the high category and

the posttest gets 91.53% in the very high category, so that the interpretation aspect increases by 9%. In the Analysis aspect, the pretest results obtained 77.42% in the Currently category and the posttest obtained 91.83% results in the very high category, so that the Analysis aspect increased by 18%. In the Evaluation aspect, the pretest results obtained 57.25% in the low category and the posttest obtained 78.22% in the high category, so that the Evaluation aspect increased by 42%. In the Inference aspect, the results of the pretest were 46.77% in the very low category and in the posttest, the results were 69.35% in the Currently category, so that the Inference aspect increased by 48%.

In this study, the criteria for effectiveness were seen based on the validity of the media developed according to experts, classical learning completeness, and N-Gain scores. On the validity of the media developed according to media experts, it gets an average of 4.75 from all aspects with a valid category, according to material experts, it gets an average of 4.82 from all aspects with a valid category, the results from user experts get an average of 4.83 from all aspects with a valid category.

Classical completeness from the results of critical thinking skills in the pre-test, namely the number of students who completed was 17 students out of 31 students (54.84%) while in the post-test the number of students who completed was 25 out of 31 students (80,65%). Thus, classically on the results of the critical thinking ability test, students have met the criteria for achieving completeness because more than 80% of students have completed it. From this explanation, it can be concluded that the mastery of student learning has been achieved classically.

The results of increasing students' critical thinking skills get the average obtained in the field trial is 0.5 with the "Currently" category. With the result that 7 students got N-Gain scores in the gain range > 0.7 which experienced an increase in the "High" category, there were 14 students who got N-Gain scores in the range $0{,}3 < g \leq 0{,}7$ that experienced an increase in the " Currently " category, and there are 8 students who get an N-Gain score in the range $g \leq 0{,}3$ that has increased in the "Low" category. So it can be concluded that Desmos E-LKPD based on Problem Based Learning is effective.

Mualdin and Edi in (Fitri et al., 2017) the practical aspect can be met if: (1) experts state that what is being developed can be applied and (2) the facts show that what has been developed can be applied. This was also reinforced by the results of validator's assessment which stated that the media that had been developed was suitable for use with little or no revision. In this study, the developed E-LKPD learning tool is said to be practical if it meets the following criteria: (1) practitioners' assessment that the E-LKPD can be used with little or no revision, (2) the results of the student response questionnaire and the results of the teacher questionnaire as E-LKPD users.

Media experts stated that the Desmos E-LKPD based on Problem Based Learning was appropriate to use with revisions according to suggestions, material experts stated that the Desmos E-LKPD based on Problem Based Learning was feasible to use without revision, and user experts stated that the

Desmos E-LKPD based on Problem Based Learning was appropriate to use with revisions according to suggestions.

The result of the students response questionnaire assessment get a percentage of 80,31% which states that the developed Desmos E-LKPD based on Problem Based Learning gets the "Good" category. The result practicality questionnaire for teacher the total percentage from all aspects get 92,18% which states that the developed Desmos E-LKPD based on Problem Based Learning gets the very practival category.

CONCLUSIONS AND RECOMMENDATIONS

Electronic student worksheets (E-LKPD) Desmos based on problem-based learning developed can improve students' critical thinking skills. This is because, in the field trial, the results of the pre-test and post-test students experienced an increase in every aspect of critical thinking ability assessment. The interpretation aspect increased by 9%, the analysis aspect increased by 18%, the evaluation aspect increased by 42%, and the inference aspect increased by 48%.

Student responses after using the Desmos Electronic Student Worksheet (E-LKPD) based on problem-based learning were in a good category. Student responses were seen from the results of the questionnaire given after the problem-based learning-based Desmos E-LKPD was used, including the assessment of aspects of contents, media, and Desmos E-LKPD Functions. From all aspects obtained a total percentage of 80.31% in the "Good" category.

Electronic student worksheets (E-LKPD) Desmos based on problem-based learning developed have met the criteria of being effective and practical. The effectiveness criteria in terms of: (1) The results of the validity of the media experts are in the valid category with an average of 4.75, the results of the validity of the material experts are in the valid category with an average of 4.82, and the results of the experts are in the valid category with an average of 4.83 (2) classical learning completeness has been achieved by 80,65% (3) Gain results are at 0.5 with a currently category. Practicality criteria are seen from: (1) Media experts stated that the Desmos E-LKPD based on Problem Based Learning was appropriate to use with revisions according to suggestions, material experts stated that the Desmos E-LKPD based on Problem Based Learning was feasible to use without revision, and user experts stated that the Desmos E-LKPD based on Problem Based Learning was appropriate to use with revisions according to suggestions (2) the results of the student response questionnaire assessment get a percentage of 80.31% which states that the developed E-LKPD gets the "Good" category and the result practicality questionnaire for teacher the total percentage from all aspects get 92,18% which states that the developed Desmos E-LKPD based on Problem Based Learning gets the very practival category

FURTHER STUDY

This research still has limitations. So it is necessary to do further research related to the topic. Researchers can use other variables in learning in the classroom.

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