



Development Of the SPLTV Geogebra Book In Mathematics Learning To Improve Students' Critical Thinking Ability

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Article Info

Article History:

Received 22
September 2023
Accepted 24
December 2023
Published 30 Januari
2024

Keywords:

*Geogebra, SPLTV,
Critical thinking.*

Abstract

This research aims to determine the process of developing the Geogebra Book SPLTV mathematics learning media to improve students' critical thinking skills. The research method used in this research is Research and Development with the ADDIE model, namely Analysis, Design, Development, Implementation and Evaluation. The research results refer to each stage of ADDIE. In the analysis stage, researchers analyzed the material and students' needs to find out the problems and determine appropriate media development solutions to overcome these problems. In the Design Stage, researchers design development products from learning outcomes to linking material to critical thinking indicators. Development stage, researchers start designing the cover, creating the contents of the geogebra book and ending with the media that will be developed. Next, the media is validated by media experts and material experts. The assessment from media experts received a percentage of 83.6%. The assessment from material experts received a percentage of 85.2% so that the media was declared ready to be used in the Implementation stage. In the Implementation Stage, the media is used in the learning process and then its suitability is measured through a student response questionnaire, getting a percentage of 85.78%, which means the media is suitable for use. The Evaluation stage measured the effectiveness of Geogebra media, getting an N-Gain score of 1.17157 and learning completeness exceeding 80% so that the media was considered effective in improving students' critical thinking skills.

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INTRODUCTION

The Indonesian government officially established the National Assessment (AN) in 2021 through Ministry of Education and Culture Regulation (Permendikbud) Number 17 of 2021, where the National Assessment is used as an evaluation of the education system at primary to secondary levels to measure cognitive and non-cognitive abilities and environmental quality. study in educational units (Kemendikbud, 2023). There are three parts of the National Assessment, including the Minimum Competency Assessment (AKM) which is used to measure the literacy and numeracy abilities of students in Indonesia. The Character Survey is used to measure students' attitudes, values, beliefs and habits which are a benchmark for student character. Learning Environment Survey to see the conditions and environment where students study (Kemendikbud, 2023).

Literacy abilities in AKM are simply defined as the abilities needed by students in reading and writing (Ranaweera, 2021). Meanwhile, students need Numeracy Ability in terms of knowledge, skills, behavior and attitudes to solve mathematical problems in various contexts (Singh et al., 2023). However, students in Indonesia tend to find it difficult to solve problems that require critical thinking skills, especially solving numeracy problems which are still in the low category (Widya et al., 2023). So there is a need for a learning and learning process that can foster critical thinking skills.

In the world of education, critical mathematical thinking skills are very important for students. According to Jiran Dore et al. (2020) critical thinking skills can help students gain a deep understanding of a problem. Even though critical thinking skills are considered important, in reality there are still many students in Indonesia who have low critical thinking skills. Research conducted by Susilawati et al. (2020) in analyzing the critical thinking abilities of students at SMAN 1 Woha, the results showed that 21%

of students had moderate critical thinking abilities, 64% of students had low critical thinking abilities and 15% of students had very low critical thinking abilities. Researchers obtained an education report card at SMA Nusaputera Semarang in 2023 regarding the achievements of the national assessment (AN) results whose scores were converted into the range 0-100. AN's report card score on numeracy ability in 2022 was 71.11 but there was a decline in AN in 2023 on numeracy ability getting a report card score of 66.67

The decline in AN's report card score on numeracy ability was caused by several factors. According to Murniati & Partiw (2023), these factors are students' low interest in getting high grades during AN and lack of understanding of questions, reasoning and students' low critical thinking patterns in answering questions. Students' critical thinking patterns are influenced by several factors. According to Murniati & Partiw (2023), factors that influence critical thinking skills in mathematics learning are 1) good physical condition of students, 2) intellectual development of students which continues to get better as they get older and 3) learning motivation of students who are focused and persistent in solving problems.

According to Arif et al. (2020) students can gain critical thinking skills by using the problem based learning model because this model can increase students' thinking activities, create habits for students to be ready to face problems and develop critical thinking skills. This is in line with the opinion of Rafidah et al. (2023) where the aim of the Problem Based Learning (PBL) model is to lead students to discover their own concepts through problem activities conceptualized by the teacher in learning. The research results of Cahyani et al. (2021) show that the problem based learning model increases students' self-discipline and critical thinking abilities. The use of the problem based learning model needs to be combined with interactive media that is interesting and makes it easier for students to discover their own concepts (Arif et al., 2020).

One of the interactive media that helps students to understand mathematical concepts

more easily, especially algebra and geometry, is Geogebra. The use of Geogebra in mathematics learning is considered to be able to make it easier for students to understand the material (Muliani et al., 2021). Geogebra can make students interested and more active in learning (Kirana et al., 2021). According to Owusu et al. (2023) mathematics teachers or mathematics lecturers must be encouraged to integrate Geogebra in learning mathematical concepts, so that they can improve student achievement and develop interest in learning mathematics.

According to Lestari & Sundi (2021) One of the high school mathematics materials that requires visual media is the material on the system of linear equations in three variables (SPLTV). This material is included in the minimum competency assessment indicator in the Algebra domain which received a score of 56.5 on the 2023 SMA Nusaputera Semarang education report card. Many students have not been able to solve problems in the SPLTV material. These student errors are often found when students translate story problems into mathematical sentences, choose the wrong steps to solve problems and make mistakes in arithmetic operations (Sigit et al., 2018). Research by Supartinah et al. (2021) that the form of errors made by students when solving SPLTV problems is in algebraic operations, students do not make mathematical models correctly, make operational errors in equations or create new equations, enter the wrong results from known or found variables and draw conclusions after each variable is found. This happens because students still have difficulty in understanding and learning mathematical concepts, one of which is the SPLTV material. One of the factors that makes students experience difficulties in learning mathematics is the lack of variation in teacher teaching and also the use of learning media and teaching materials that are not optimal (Rahman & Fauziana, 2018).

Based on the description above, to improve students' critical thinking skills that will be used in solving problems. Especially in working on AKM questions that contain High Order Thinking Skill (HOTS) type questions, especially

on SPLTV material, researchers are interested in conducting research on the development of SPLTV geogebra books with the Problem based learning (PBL) model to improve high school students' critical thinking skills.

METHOD

The research method used in this study is research and development, which is a research method used to produce certain products, and test the effectiveness of the product (Sugiyono, 2015). The population in this study were high school students at SHS Nusaputera Semarang in the 2024/2025 academic year. The development design used in this study is the ADDIE model. This model consists of five main phases or stages, namely (A)nalysis, (D)esign, (D)evelopment, (I)mplementation, and (E)valuation.

Analysis is carried out on the conditions and needs of the research subjects, namely low AKM values and lack of utilization of learning media technology. Design is carried out before the development step, usually in the form of a content framework for the media to be developed to suit existing conditions and needs. Development is carried out by compiling and creating media according to the planned design to become a product that is ready to use. Implementation of products that have been made to obtain evaluation results by product users. Evaluation as a form of improvement or satisfaction by product users. If the product gets a lot of input or improvements, the researcher must repeat it from the initial stage according to the existing comments.

RESULTS AND DISCUSSIONS

The research results refer to the ADDIE research design, first performance and needs analysis. The researcher conducted a preliminary study by interviewing one of the mathematics teachers, namely Mr. Kurnia Hendra Wijaya, S.Pd., M.Pd. who teaches class X. Based on the interview results, several things can be concluded related to performance analysis. : 1) Teachers do not yet understand the independent curriculum,

especially the learning outcomes (CP) set by the Ministry of Education and Culture, so that learning objectives are not yet centered on students with contextual material. 2) The independent curriculum changes the RPP into a Teaching Module (MA) which aims to summarize and combine the RPP with teaching materials into one part, this makes teachers often use MA as teaching materials in learning. 3) Teachers often have difficulty implementing the PBL model in the classroom because students tend to want the teacher to explain the material first and then the teacher gives practice questions. 4) There has been no application of the use of learning media because teachers have not been able to make students interested in media-assisted learning in mathematics learning. Then the needs analysis includes student needs analysis, curriculum analysis, and material analysis. The following is the explanation: 1) Analysis of student needs is carried out by conducting observations to collect data on what students need. The results of the observation show that students need innovative, interesting, and

practical learning media that can help in the learning process so that it is easier to understand mathematics learning materials. Therefore, researchers developed the SPLTV geogebra book as an interesting and innovative learning media. 2) Curriculum Analysis Curriculum analysis aims to determine the curriculum applied in schools as a reference in developing this learning media. After conducting observations at SMA Nusaputera, the curriculum used is the independent curriculum. 3) Material Analysis Based on the independent curriculum in the mathematics subject of grade X phase E, one of the materials studied is the Three Variable Linear Equation System . The second stage of design aims to design a design in developing the SPLTV geogebra book that is oriented towards the critical thinking skills of high school students. The things needed in compiling the product are determining the subjects developed, namely the mathematics subject of SPLTV material. Then identify learning outcomes (CP) and Learning Objective Flow (ATP), here is the CP and ATP table of SPLTV material.

Table 1. Learning Outcomes and Learning Objective Flow

Learning Outcomes	Learning Objectives
At the end of phase E, students can solve problems related to systems of linear equations in three variables..	A.1 Modeling the problem into a system of linear equations of three variables. A.2 Solve problems related to systems of linear equations in three variables.

Next, identify the indicators of critical thinking that can be seen in the implementation of research. The aim of this research is to measure the increase in critical thinking skills, therefore the media to be developed must refer to critical

thinking indicators. The following indicators of critical thinking are visible in the SPLTV geogebra book.

Table 2. Indicators Of Critical Thinking Ability Geogebra Book SPLTV

Aspects of Critical Thinking	Visible indicators
Interpretation	Write down what is known, asked, and carry out mathematical modeling accurately and correctly of the SPLTV problem being asked
Analysis	Determine the method for solving SPLTV problems, and carry out calculations appropriately and correctly
Evaluation	Write solutions to SPLTV problems accurately and correctly and be able to use other alternative answers
Inference (Conclusion)	Make conclusions from the results that have been found to answer SPLTV problems
Explanation	Present and give reasons in the form of convincing arguments
Self Regulation	Double-check the results of completing the questions accurately and correctly using the Geogebra 3D calculator feature and make corrections from teachers or peers

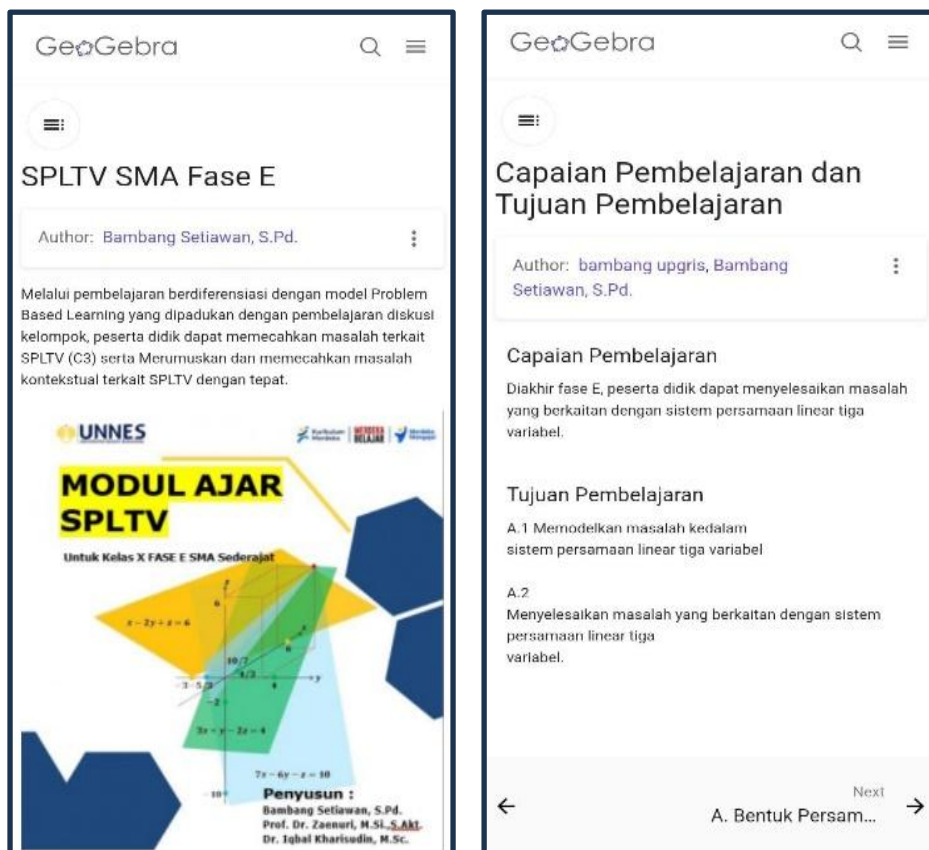


Figure 1. View of the cover and CP TP geogebra book SPLTV on a cellphone

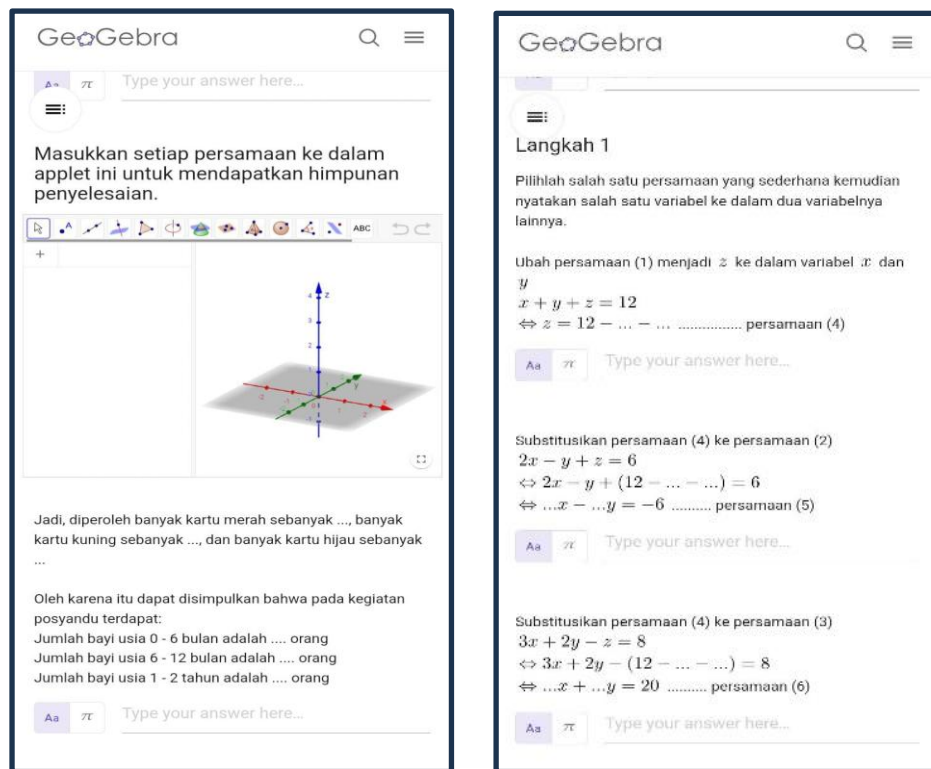


Figure 2. Geogebra Applete and Geogebra Book SPLTV

The SPLTV geogebra book product with a Problem Based Learning model which is oriented towards critical thinking skills as a result of this development is tested for feasibility levels to determine deficiencies

that need to be corrected and need to be added to learning media before being tested further on students. The results of media and material validation are as follows

Table 3. Validation Results of Learning Media Expert Assessment

No	Assessment Aspects	Observation Score		Maximum Score	Eligibility	
		I	II		I	II
1	General	19	17	20	95%	85%
2	Desain	38	36	45	84.4%	80%
3	Content	23	22	25	92%	88%
4	Language	12	12	15	80%	80%
5	Media Practicality	18	16	20	90%	80%
Total Score		110	103	125	88%	82.4%
Final Percentage					85.2%	

Based on the calculation above, it is known that the percentage of achievement level is 85.2%. After being converted using the scale conversion table, the achievement level percentage of 85.2% is in the "Very Good" criteria. However, this media still has shortcomings that need to be

revised. The revision process was carried out by considering the results of the review and suggestions provided by media experts. So it can be concluded that the learning media is worth trying out with the need for slight revisions.

Table 4. Learning Media Expert Revision

Media Expert	Validator Name	Media Expert Advice
Expert I	Emanuel Suryajaya, S.Kom	Instructions for using the Geogebra book need to be provided at the beginning so that students can use it easily and smoothly.
Expert II	Elfa Mawadati, S.Pd.	The steps for using the Geogebra applet are displayed.

Next, analyze the validation of material media which is oriented towards the critical experts. The development product submitted to thinking skills of high school students. The learning materials experts for validation is the following are the results of material expert Geogebra Book SPLTV mathematics learning validation.

Table 5. Results of Validation of Learning Material Expert Assessment

No	Assessment Aspects	Observation Score		Maximum Score	Eligibility	
		I	II		I	II
1	General	19	16	20	95%	82%
2	Material Substance	61	56	70	87%	80%
3	Use of Language	12	12	15	80%	80%
4	Learning Design	17	16	20	85%	80%
Total Score		109	100	125	87.2%	80%
Final Percentage					83.6%	

Based on the calculation above, it is known that the percentage of achievement level is 83.6%. After being converted using the scale conversion table, the achievement level percentage of 83.6% is in the "Very Good" criteria. However, this media still has shortcomings that need to be revised. The revision process is carried out by considering the results of the review and suggestions provided by material experts. So it can be concluded that learning media is worth testing with revisions.

Table 6. Expert Revision of Learning Materials

Materials Expert	Validator Name	Material Expert Advice
Expert I	Kurnia Hendra Wijaya, S.Pd., M.Pd.	Nothing
Expert II	Elfa Mawadati, S.Pd.	Incorporate a more contextual approach to the problem

The fourth stage is the implementation stage (product trial). At this stage the researcher implemented the geogebra book which had been developed in a real situation, namely in the experimental class (class X-1). Researchers will guide students to achieve learning goals, solve problems or solutions to overcome gaps in their critical thinking abilities. In the initial stage of this research, the researcher first tested the question instrument in class X Excellent as a trial class to determine the validity, reliability, level of difficulty and differentiating power. This is done to prepare instruments that will be tested in experimental class and control class tests. The class that will be taken as an experimental class is class X-1, a class where learning will use the Geogebra book. Meanwhile, the class taken as the control class was class X-2, a class whose learning did not use Geogebra books. From the results of the trial questions, the results show that only questions with valid categories and significant differentiating power can be used as research

instrument questions. Based on the results of the validity, reliability, level of difficulty and differentiating power of the 10 instrument questions that were tested, 6 questions were obtained that were suitable to be tested in the experimental class and control class.

Table 7. Results of Analysis of Trial Questions

No	Validity		Reliability		Difficulty Level		Differentiating Power		Information
	Score	Criteria	Score	Criteria	Score	Criteria	Score	Criteria	
1	0.909	Valid	0.788	Reliable (Very High)	0.838	Easy	0.275	Nice	Worn
2	0.210	Invalid			0.407	Medium	0.075	Bad	Throw
3	0.164	Invalid			0.438	Medium	0.025	Bad	Throw
4	0.873	Valid			0.361	Medium	0.525	Very good	Worn
5	0.145	Invalid			0.269	Hard	0.025	Bad	Throw
6	0.912	Valid			0.615	Medium	0.4	Very good	Worn
7	0.829	Valid			0.507	Medium	0.3	Good	Worn
8	0.249	Invalid			0.430	Medium	0.05	Bad	Throw
9	0.891	Valid			0.323	Medium	0.25	Nice	Worn
10	0.312	Invalid			0.430	Medium	0.05	Bad	Throw

The fifth stage is the evaluation stage. At this stage the researcher carried out a formative evaluation at the end of the face-to-face meeting to determine students' critical thinking abilities after carrying out learning using the Geogebra book SPLTV with a problem based learning model and those given conventional learning on SPLTV material. Based on the data analysis described above, the researcher carried out initial data analysis to find out whether the data from the experimental class and control class came from the same initial conditions or not. The data used for this initial data analysis comes from test scores before being given treatment (pre-test), namely test scores in classes X-1 and X-2. The data was then tested using the normality test, homogeneity test and two-tailed t test. From the results of the normality test that was carried out on the experimental class and control class, it was proven that the two samples came from a normally distributed population. After the two samples were proven to come from a normally distributed population, a homogeneity test was then carried out with the aim of finding out whether the variances of the two groups were the same (homogeneous). From the results of the homogeneity test that was carried out, it was

proven that the variances of the two groups were the same (homogeneous). After the two classes were proven to be normal and homogeneous, a two-tailed t test was then carried out to find out whether the two classes had the same average critical thinking abilities. From the results of the two-party t test that was carried out, it was proven that the average critical thinking ability between the experimental class and the control class was no different (the same).

Table 8. Results of Initial Data Normality Test Analysis

Class	n	L_{hitung}	L_{tabel}	Conclusion
Experiment	28	0.115	0.166	Normally distributed
Control	28	0.163	0.166	Normally distributed

Table 9. Results of Initial Data Homogeneity Test Analysis

Class	n	b_{hitung}	b_{tabel}	Conclusion
Experiment	28	0.99	0.93	Homogeneous Variance
Control	28			

Table 10. Two Party t Test Results Initial Data

Class	n	t_{hitung}	t_{tabel}	Conclusion
Experiment	28	0.25	1.67	The average critical thinking ability for both classes is the same
Control	28			

After the initial data test is complete, a series of learning is carried out according to the teaching module that has been created. Next, a post test was carried out for final data analysis. Final data analysis was used to calculate post test data to find out whether there were differences in critical thinking abilities between the experimental class and the control class.

Table 11. Final Data Normality Test Results

Class	n	L_{hitung}	L_{tabel}	Conclusion
Experiment	28	0.095	0.166	Normally distributed
Control	28	0.121	0.166	Normally distributed

Table 12. Final Data Homogeneity Test Analysis Results

Class	n	b_{tabel}	b_{hitung}	Conclusion
Experiment	28	0.954	0.930	Homogeneous Variance
Control	28			

Table 13. Right Side t Test Results Final Data

Class	n	t_{hitung}	t_{tabel}	Conclusion
Experiment	28	1.79	1.67	The critical thinking average of the experimental class is better than the control class
Control	28			

After learning has been carried out for 1 meeting, a post test will then be carried out in the experimental class and control class. This was done to find out whether the critical thinking skills of students who used the Geogebra book were better than students who used conventional learning models. The results of the post test data

were then tested using the normality test, homogeneity test, and right-hand t test. In the final data normality test, it was found that both classes had a normal distribution. In the final data homogeneity test it was also found that the two classes were homogeneous. In the right-hand t test, it was found that the average critical thinking ability of the class that used the developed Geogebra book was better than the average critical thinking ability of the class that used conventional learning.

The N-Gain test was carried out after the pre-test and post-test scores from the experimental class and control class. The purpose of the N-Gain test is to determine whether or not there has been an increase in students' critical thinking abilities. The following are the results of increasing students' critical thinking skills as shown using the N-Gain test.

Table 14. Improvement in Critical Thinking Ability of Experimental Class Students

Question	N-Gain	Category
1	0.304347	Hard
2	0.711711	Hard
3	0.4	Medium
4	0.809523	Hard
5	0.755102	Hard

Table 15. Increase in Critical Thinking Ability of Control Class Students

Question	N-Gain	Category
1	0.242424	Low
2	0.507462	Medium
3	0.327272	Medium
4	0.728813	Hard
5	0.701086	Hard

The conclusions obtained from the N-Gain results for the experimental class and control class.

Table 16. Conclusion of N-Gain Results

No.	Class	N-Gain	Category	Media Design	465	560	83.03%
				Practicality	504	560	90%
1.	Experiment	0.6091	Medium	Total	2402	2800	85.78%
2.	Control	0.5199	Medium				

The results obtained from the N-Gain calculation were that in the experimental class there was an increase of 0.6091 in the medium category and in the control class there was an increase of 0.5199 in the medium category.

Next, a learning effectiveness test will be carried out to find out whether the product is effective to use or not. Effectiveness is carried out using the N-Gain test. Based on the effectiveness of the N-Gain test, the effectiveness was found to be 1.17157 which falls into the effectiveness category > 1 . This means that the Geogebra book SPLTV with problem based learning is more effective than conventional learning without using the Geogebra book SPLTV with problem based learning. Apart from using the N-Gain Test, the product is said to be effective. By analyzing learning completeness, data was obtained that students' critical thinking skills using the Geogebra book SPLTV with problem based learning can reach the KKM.

After the product was tested in the experimental class and the researcher had carried out a post test, the next step was for the researcher to take student responses in the experimental class (class X-1) to determine the feasibility and practicality of the Geogebra book SPLTV with problem based learning using a student questionnaire.

Table 17. Results of Analysis of Student Responses

Assessment Aspects	Score Observ	Score Max	Eligibility
General	500	560	89.28%
Material Substance	352	420	83.80%
Language Eligibility	218	280	77.85%
Exercises	363	420	86.42%

From the results of the student questionnaire, it shows that the percentage of achievement level is 85.78%. This percentage is then converted into quality criteria so that it can be concluded that the Geogebra book SPLTV with problem based learning which is oriented towards the critical thinking skills of high school students is included in the very good category.

Based on the discussion above, this research shows that the critical thinking skills of students in the experimental class which uses the Geogebra book SPLTV with problem based learning are suitable for use and are better than the critical thinking skills of students in the control class which uses conventional learning.

CONCLUSION

Based on the results of the analysis and discussion in this research, it can be concluded that: (1) The development of the Geogebra book SPLTV with problem based learning oriented towards the critical thinking skills of high school students was declared valid (suitable) for use by looking at the validation assessment from media experts at 85.2% and material experts at 83.6% in the very good category. (2) The development of the SPLTV geogebra book with problem based learning which is oriented towards the critical thinking skills of high school students is stated to be practical to use by looking at the assessment from the student questionnaire. The student questionnaire showed that the percentage of eligibility for Geogebra Book was 85.78%. This percentage is in the very good practical value category. (3) The development of the SPLTV geogebra book with problem based learning which is oriented towards the critical thinking skills of high school students is said to be effective, because the N-Gain test results obtained were 1.17157 and also in the classical learning completeness analysis data was obtained that the

critical thinking abilities of students who used geogebra book SPLTV with problem based learning exceeds 80%, namely at a percentage of 100% so that it can reach the KKM.

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