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Implementation of the STEM-GeoGebra Integrated PjBL Model to Improve Student's Critical Thinking Skills

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Abstract*: The process of learning mathematics is in fact still not fully able to develop students' critical thinking skills. The importance of critical thinking for students lies in good problem solving methods. This study aims to describe students' critical thinking skills after implementing the STEM-GeoGebra integrated PjBL model and to find out students' responses. Students' critical thinking skills in learning mathematics are still low, as evidenced by the learning outcomes of students who have not yet reached the KKTP. A quantitative approach with the Pre-Experimental Designs One Group Pre-test Post-test design was used in this study. The target of this study-09 was class VII-C students of SMP Negeri 2 Surabaya for the 2022/2023 academic year with a total of 33 students. The method for implementing the STEM-GeoGebra integration PjBL model is carried out in 6 stages: 1) Problem recognition, 2) Project planning, 3) Developing project plans, 4) Evaluation of project progress, 5) Evaluation of project results, and 6) Evaluation of experiences. The instruments used were test questions and student response questionnaires that had been declared eligible for field tests by the validator. The study results show that students' critical thinking skills have increased, this is indicated by the large N-gain value of 0.42 in the medium category and the students' responses are in the good category with an average of 75. Furthermore, the results of this study indicate that there is an increase in critical thinking skills through the application of the STEM-GeoGebra integration PjBL model..*

Keywords*: critical thinking; one group pretest post-test; pre-experimental designs; project based learning, stem-geogebra.*

INTRODUCTION

Mathematics has an important role in the development of science and technology (IPTEK). This is because mathematics has a relationship with concepts that can train rational thinking. Mathematics is taught to equip students with the ability to think logically, analytically, systematically, critically, innovatively and creatively, and cooperate (Rachmantika & Wardono, 2019). Mathematics often appears in other subjects, because mathematics is a basic science that can help solve problems in various fields of science (Pratomo et al., 2020). The mathematics learning process in reality still cannot fully develop students' critical thinking skills. This is because the development of student's critical thinking skills is still relatively low so students find it difficult to work on math problems. The importance of critical thinking for students lies in solving good problems, believing all decisions made, and not easily concluding something immediately. Critical thinking skills according to (Nurul et al., 2022) aim to get rational decisions so that the truth that is considered the best can be done correctly. Facts in the field show that critical thinking skills are relatively low, including mathematical critical thinking skills (Suherman et al., 2021). Teachers have an important role in choosing the right learning model and media for students to attract interest in learning (Yuliana et al., 2017). The selection of the right learning model plays a role in improving students' mathematical critical thinking skills (Amalia & Suryaningtyas, 2023). The learning model that prioritizes critical thinking skills is the Project Based Learning (PjBL) model (Pratiwi & Setyaningtyas, 2020).

According to Thomas, the PjBL model is a learning model that organizes lessons in project-based learning (Hartono & Asiyah, 2018). Meanwhile, according to Gulbahar & Tinmaz, the main characteristic of project-integrated learning is to instruct and enable learners

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to discover concepts from a discipline through constructive research (Priatna et al., 2020). Project-based learning (PjBL) is a learning model that uses a process-centered, problem-focused approach as a start in integrating new knowledge based on real experiences (Solekhah et al., 2018). The PjBL model provides ample opportunities for learners to use thinking and action skills both individually and collaboratively (Wibowo et al., 2018). The main focus of the PjBL model is to familiarize students to overcome and solve the problems given, emphasize the products produced, and stimulate the development of critical thinking skills. The PjBL model is an innovative learning model that requires students to think creatively, critically, and interactively by producing products for projects that are done at the end of learning (Rani et al., 2021). The PjBL learning model is considered to provide meaningful and interesting learning experiences, students build their knowledge by producing projects based on real experiences resulting from cooperation in groups (Amin et al., 2022). This PjBL model is implemented in the form of projects, where students are free to carry out activities because this learning model is learner-centered. Continuous efforts to integrate learning through projects require learning approaches that are relevant to everyday life.

One method that can be used for project activities is STEM (Science, Technology, Engineering, and Mathematics). STEM is an education method where Science, Technology, Engineering, and Mathematics are integrated with the educational process focusing on solving problems in real life as well as in professional life (Davidi et al., 2021). STEM integration focuses on solving real-life problems. There are four disciplines covered by STEM, namely 1) science is knowledge obtained through experimental testing and observation, which refers to the principles of the thing being researched and studied; 2) technology is a tool used to support knowledge in other fields, used to help humans in their work and provide comfort for human life itself; 3) engineering is a method or design to do what is desired; 4) mathematics is a science that involves numbers, the relationship between numbers (Rachmantika & Wardono, 2019). Aims to develop learners' abilities in these four areas of knowledge. The STEM- integrated PjBL model is a learning model that provides students with a project to solve problems and is based on STEM aspects, namely Science, Technology, Engineering, and Mathematics (Sriyanto, 2021). The STEM integrated PjBL model requires students to think critically, and analytically and develop higher-order thinking skills (Priatna & Lorenzia, 2018). The steps of the STEM-integrated PjBL model used in this study have been modified according to the George Lucas Educational Foundation in (Diana & Saputri, 2022) are as follows: 1) problem introduction, 2) project planning, 3) preparation of a work plan, 4) supervising the course of the project, 5) evaluating project results and 6) evaluating the experience.

The results of preliminary observations that have been made at SMP Negeri 2 Surabaya show that one of the learning problems at school is that most of the learning is only centered on the educator, so the interaction between students and educators is still lacking. The learning model used by educators is less varied and the learning process tends to only take place through discussion and question-and-answer activities followed by an explanation of the material through the lecture method. Therefore, students feel bored and saturated when learning takes place. In addition, the critical thinking ability of students in learning mathematics is still low, this is due to the efforts made to provide guiding questions in directing students to think critically is still lacking and the learning outcomes of students are still below average or not passing KKTP (Criteria for Achievement of Learning Objectives).

Several previous studies have examined and found positive results related to the application of STEM-integrated PjBL to improve critical thinking skills. The results of the first study, conducted by (Priatna et al., 2020) with the research title "Rural Development of STEM-Integrated Project-Based Learning Model to Improve Mathematical Critical Thinking Ability of Junior High School Students", obtained the results of this study, namely the PjBL model integrated with STEM can improve the mathematical critical thinking ability of students in class IX-A SMP Negeri Bandung City. The results of the second study, by (Indriani, 2020) with the research title "Improving Students' Mathematical Thinking Ability on Flat Buildings Material Through STEM Integrated Project Learning Model", obtained the results that the application of the STEM integrated project learning model can improve students' mathematical thinking ability on flat building material in class VIII SMPN 4 Taliwang. The third research result, (Rahmawati et al., 2022) with the research title "Implementation of STEM in Improving Mathematical Critical and Creative Thinking Ability", found that the STEM approach has a positive effect on improving mathematical creative thinking and critical thinking abilities. STEM is project-based with the PjBL learning model so that STEM-PjBL integration can be used by educators as an effort to hone creative thinking skills and mathematical critical thinking skills. Reflecting on previous research, researchers tried to apply the STEM integration PjBL model assisted by GeoGebra media to determine the improvement of students' critical thinking skills on data usage material in class VII-C SMP Negeri 2 Surabaya. The indicators of critical thinking skills used in this study are modified according to (Suryani & Haryadi, 2022) which are translated into several sub-skills, namely interpretation, analysis, evaluation and inference. Students can fulfill the interpretation indicator category if students can write down important information from the problem, namely what is known and asked from the problem. Learners can meet the analysis indicator category if students can analyze problems from the context of the problem by writing the mathematical model and information correctly and completely. Learners can fulfill the evaluation category if students can use the right, complete, and correct way of doing calculations or explanations from the context of the problem. Learners can fulfill the inference indicator category if students can conclude correctly, completely according to the context of the problem.

The use of GeoGebra as a learning media makes it easier for educators to convey material and students are easy to understand because there are animated simulations and manipulation actions (dragging) that provide a clearer visual experience to students (Kamilah et al., 2019). In addition, the GeoGebra-assisted STEM integration PjBL model can also provide opportunities for students to make discoveries through manipulating these props, so that they can build students' critical thinking skills. GeoGebra application has the potential to generate conciseness and interaction in learning about math, science, and STEM-related topics through its dynamic features (Ziatdinov & Valles, 2022).

Based on the description above, this study aims to describe the critical thinking skills of students after applying the STEM-GeoGebra integrated PjBL model in class VII-C SMP Negeri 2 Surabaya and to determine the response of students through the application of the STEM-GeoGebra integrated PjBL model in class VII-C SMP Negeri 2 Surabaya.

RESEARCH METHODS

This research uses a quantitative approach, with a Pre-experimental Designs One Group Pretest Posttes research design (Sugiyono, 2016). The study conducted treatment in the form of applying the STEM-GeoGebra integration PjBL model to see an increase in critical thinking skills.

Table 1. Research Design

Pretest	**Treatment**	***Posttests***
O_1	X	O_2

With O_1 = Pretest (before treatment), O_2 = Posttest (after treatment), X = Learning by using the PjBL Model learning model integrated with STEM-GeoGebra. The research target at SMP

Negeri 2 Surabaya in class VII-C which amounted to 33 students. The reason for choosing class VII-C is that individually there are still many students who have not reached the minimum completeness criteria value of KKTP 70. In addition, the selection of class VII-C is also on the recommendation of the educator.

The application of the STEM-GeoGebra integration PjBL model consists of 6 stages, namely: 1) introduction to the problem, educators provide a trigger question, 2) project planning, students plan projects contained in the lkpd, and 3) develop a project plan, students set the time to complete the project. 4) evaluate the course of the project, learners consult with educators regarding the project that has been done. 5) evaluation of project results, students present the results of project work and 6) evaluation of experience, students tell their feelings and experiences while working on the project. Data were collected using the test method and questionnaire method. The test question aims to determine the existence of an increase in the critical thinking ability of students after being given treatment in the form of applying the STEM- GeoGebra integration PjBL learning model, the form of the question is an essay with a total of 4 questions and the maximum score is 100 points. The following is the formula for the percentage analysis technique used for data analysis:

$$Percentage = \frac{Total\ Score}{Maximum\ Score} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The categories given are designed to determine the percentage of the feasibility of students' critical thinking skills.

Table 2. Percentage Qualification of Critical Thinking Skills

Category	Percentage
Very Critical	80% ≤ A ≤ 100%
Critical	60% ≤ B < 80%
Critical Enough	40% ≤ C < 60%
Less Critical	20% ≤ D < 40%
Not Critical	0% ≤ E < 20%

(Khasanah & Ayu, 2017)

The student response questionnaire is used to find out the students' responses to the learning of the PjBL learning model integrated with STEM-GeoGebra, the student response questionnaire consists of 10 statements, namely 5 negative statements and 5 positive statements.

The results of the pretest and posttest were used to measure critical thinking skills which were analyzed by giving a score to each student's answer, then describing the critical thinking skills of students. In addition, to see an increase in students' critical thinking skills before and after the application of the STEM-GeoGebra integrated PjBL model, an analysis was carried out using the N-gain calculation based on Hake (Holisin et al., 2019). The N-gain formula used is:

$$N - gain = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

with S_{post} = Final test score, S_{maks} = Maximum score, S_{pre} = Initial test score, *N-gain* scores are grouped as follows (Holisin et al., 2019):

Table 3. Classification of N-gain Score Interpretation

N-gain value	Category
$0 > 0{,}7$	High
$0{,}3 \leq g \leq 0{,}7$	Medium
$0 < 0{,}3$	Low

The results of the students' response questionnaire to the STEM-GeoGebra integration PjBL model were analyzed using a Likert scale. The criteria for interpreting the students' response questionnaire are shown in Table 4.

Table 4. Classification of Students' Responses To The STEM- Geogebra Integrated PjBL

Interval (%)	Letter	Description
76 – 100	A	Excellent
51 – 75	B	Good
26 – 50	C	Simply
0 – 25	D	Less

RESULTS AND DISCUSSION

This study aims to describe the critical thinking skills of students after applying the STEM-GeoGebra integrated PjBL model in class VII-C SMP Negeri 2 Surabaya and students' responses through the application of the STEM-GeoGebra integrated PjBL model in class VII-C SMP Negeri 2 Surabaya on data usage material. Before the research was conducted, the research instrument was validated by two material experts and one expert practitioner. The validation results show that the instrument used is feasible for field testing. The validation results from validator 1, validator 2, and validator 3 can be seen in Table 5, as follows:

Table 5. Validation Results of Material Experts and Practitioner Experts

Instrument From	Validator Result		
	Validator 1	Validator 2	Validator 3
Student Worksheet	Can be used with minor revision	Can be used with minor revision	Can be used without revision.
Student response questionnaire	Can be used without revision.	Can be used with minor revision	Can be used with minor revision
Learning Implementation Plan	Can be used without revision.	Can be used with minor revision	Can be used without revision.
Pretest and posttest questions on critical thinking skills	Can be used with minor revision	Can be used with minor revision	Can be used without revision.

The application of the STEM-GeoGebra integrated PjBL model in this study consists of 6 stages, namely: 1) introduction to the problem, educators provide a trigger question then students observe and answer the question, then the educator provides explanation and reinforcement related to the trigger question by applying STEM-GeoGebra, 2) project planning, students are divided into 8 groups consisting of 4 students in one group, then students observe the problems contained in the LKPD, and carry out the division of tasks for each group member, 3) develop a project plan, educators guide to set the time to complete the project, the project is done for 3 days, 4) supervise the course of the project, each group consults with the educator regarding the activities that have been carried out then the educator asks about the obstacles of each group and provides guidance to students who are still having difficulty and who have work that is not correct, then students revise the work that has been corrected by the educator, 5) Evaluation of project results, group representatives present the results of projects that have been made (Mathematics). Educators provide opportunities for other groups to respond and analyze the results of presentations including questions and answers as confirmation, 6) Evaluation of experience, students are asked to tell their feelings and experience while completing the project, then the educator evaluates and assesses the result of the projects done by students during learning.

The improvement of students' critical thinking skills after the application of the STEM-GeoGebra integration PjBL learning model was measured by written tests in the form of pretests and posttests given before and after the application of the STEM-GeoGebra integration PjBL model. There were 31 research subjects whose data were processed because there were 2 students who did not take part in the pretest, posttest, and or learning due to sick leave. The pretest and posttest results are shown in Table 6.

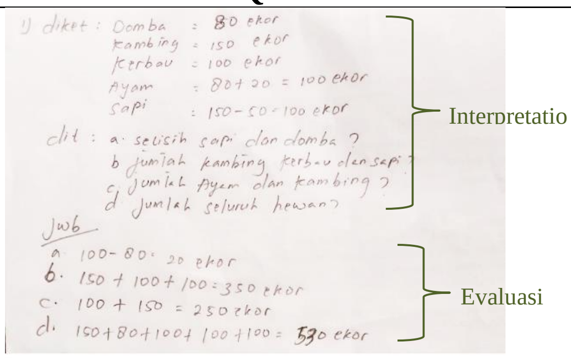
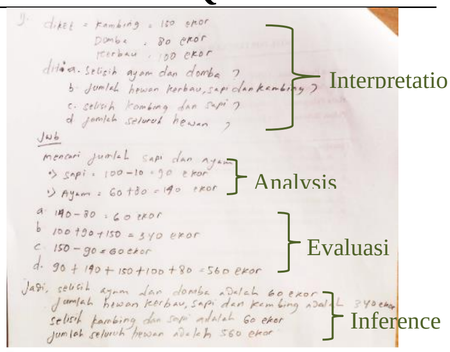
Table 6. Description of Pretest and Posttest Results

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Scores	31	0	45	19,68	12,885
Pretest Scores	31	28	81	53,48	13,033
Valid N (listwise)	31				

Based on Table 6, the minimum score obtained from the pretest is 0, and the posttest result is 28. The maximum score from the pretest is 45, and the posttest result is 81. The mean for the pretest is 19.68, and for the posttest is 53.48, with a standard deviation of 12.885 for the pretest and 13.033 for the posttest. The data shows that the post-test scores are higher than the pretest scores.

Critical thinking ability in this study is based on 4 indicators: interpretation, analysis, evaluation, and inference. The following are the students' answers in completing the pretest and posttest questions based on the indicators of critical thinking ability:

Table 7. Student Responses Based On Indicators of Critical Thinking Skills

Pretest Questions	Posttest Questions
	

In Table 7, taken from one of the student's responses at SMP Negeri 2 Surabaya, the student showed a nearly perfect analysis of the questions based on critical thinking skills and achieved the highest score in both the pretest and posttest. In the pretest questions, the students, on average, were less familiar with writing mathematical models and drawing conclusions from the context of the problems. Most of the students only wrote interpretation and evaluation indicators. However, after implementing the PjBL integrated STEM-GeoGebra learning model, the students became more accustomed to solving problems based on critical thinking indicators, such as writing interpretations, analysis, evaluation, and inferences accurately and comprehensively. As a result, the students' post-test scores showed improvement.

The percentage of each critical thinking skill indicator from the pretest and posttest results is shown in Table 8.

Table 8. Percentage of Each Critical Thinking Skill Indicator

About	Ability Critical Thinking	Problem 1	Problem 2	Problem 3	Problem 4	Average
Pretest	Interpretation	50	23	25	3	27%
	Analysis	32	8	2	0	11%
	Evaluation	77	31	12	0	30%
	Inference	16	17	0	0	9%
Posttest	Interpretation	74	76	67	53	72%
	Analysis	51	37	37	18	38%
	Evaluation	92	83	59	50	76%
	Inference	28	23	28	27	28%

Based on Table 8, the highest pretest and posttest scores are found in indicator 3, which is the evaluation indicator, with an average pretest score of 32%, categorized as less critical, and an average posttest score of 76%, categorized as critical. This shows that most of the students are capable of thinking deeply about the problems to be solved and are accustomed to working on the questions by directly presenting their solutions. The second highest score is in indicator 1, which is the interpretation indicator, with an average pretest score of 27%, categorized as less critical, and an average posttest score of 72%, categorized as critical. This indicates that most of the students can comprehend the presented questions and analyze what is known and what is being asked, but not all students can understand the questions well due to a lack of practice in solving such problems. The third highest score is in indicator 2, which is the analysis indicator, with an average pretest score of 11%, categorized as not critical, and an average posttest score of 38%, categorized as less critical. This shows that the students are lacking in connecting the question with problem-solving in the questions. The fourth highest score is in indicator 4, which is the inference indicator, with an average pretest score of 9%, categorized as not critical, and an average posttest score of 28%, categorized as not critical. This indicates that the students are not accustomed to providing conclusions from solving the problems. The accumulated average score of critical thinking skills through the PjBL integrated STEM-GeoGebra model can be seen in Figure 1.

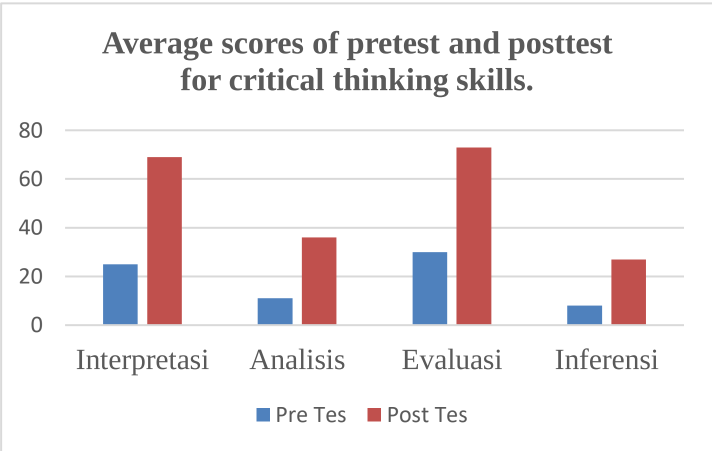


Figure 1. Average Scores of Pretest and Posttest for Critical Thinking Skills

Based on Figure 1, shows that the students more often solve problems according to the evaluation and interpretation indicators, but they are less accustomed to applying the analysis and inference indicators, resulting in relatively low average scores. This is consistent with the research findings (Suryani and Haryadi, 2022) that indicate the learning process of the subject in the study has not maximally involved activities such as analyzing, synthesizing, making considerations, creating, and applying new knowledge in the real world. Based on the results of the pretest and posttest, it is known how many students fall into the categories of critical thinking skills, as shown in Table 9.

Table 9. Number of Students According To Critical Thinking Skills Categories

Category	Description	Pretest (Total)	Posttest(Total)	Percentage Increase
80% ≤ A ≤ 100%	Very Critical	0	1	3,03%
60% ≤ B < 80%	Critical	0	9	27,27%
40% ≤ C < 60%	Critical Enough	3	18	45,45%
20% ≤ D < 40%	Less Critical	12	3	-
0% ≤ E < 20%	Not Critical	18	0	-

The data in Table 9 shows that in the pretest results, there are 3 students classified as moderately critical, 12 students classified as less critical, and 18 students classified as not critical. Meanwhile, in the posttest results, there is 1 student classified as highly critical, 9 students classified as critical, 18 students classified as moderately critical, 3 students classified as less critical, and 0 students classified as not critical. Based on this data, it can be concluded that many students were not considered critical before the implementation of the PjBL integrated STEM-GeoGebra model, as evidenced by the pretest questions. However, after the implementation of the PjBL integrated STEM-GeoGebra model, there was an improvement in students' critical thinking skills, as shown in the posttest results.

Furthermore, to determine the increase in critical thinking skills before and after the implementation of the PjBL integrated STEM-GeoGebra model, N-gain calculations were conducted using SPSS. The results of the N-gain calculations for students' critical thinking skills based on pretest and posttest scores are presented in Table 10.

Table 10. Critical Thinking Skills Based on Pretest and Posttest

	Pretest	***Posttest***	***N-gain***	**Criteria**
Average	19,68	53,48	0,42	
Standard Deviation	12,885	13,033		Medium

The data in Table 10 shows that there is an improvement in students' critical thinking skills after the implementation of the PjBL integrated STEM-GeoGebra model. This improvement is indicated by the N-gain value of 0.42, which falls into the moderate criteria. The enhancement in critical thinking skills by applying the PjBL integrated STEM-GeoGebra model for students at SMP Negeri 2 Surabaya in this study aligns with the research conducted by (Priatna et al., 2020), which stated that mathematics learning using a project-based learning model integrated with STEM can facilitate students in enhancing their mathematical critical thinking skills. It also supports the findings of (Fitriyah and Ramadani, 2021), who stated that the PjBL integrated STEM-GeoGebra model significantly affects critical thinking skills. This is because the integration of STEM and PjBL can be an innovative approach that encourages creative and critical ideas and solutions, making problem-solving easier. The PjBL integrated STEM-GeoGebra model is suitable for implementation in junior high school students as it actively involves them in problem-solving with the aid of technology, leading to an improvement in critical thinking skills.

The results of the student response questionnaire given to 33 respondents reinforce that the implementation of the PjBL integrated STEM-GeoGebra model is an appropriate learning model for enhancing students' critical thinking skills, as evidenced by an average score of 75, falling into the good category. The summary of the student response questionnaire can be seen in Table 11.

Table 11. Recapitulation of Percentage Data from The Student Response Questionnaire

No.	Indicator	Percentage		Average	Category
		Positives	Negatives		
1.	Interesting activities in education	1	4	77%	Excellent
2.	Learner motivation and needs	2	5	74%	Good
3.	Appreciation in learning	3	7	72%	Good
4.	Desire to succeed in learning	6	9	76%	Good
5.	Conducive learning environment	8	10	75%	Good
	Rata-Rata			75	Good

Based on Table 11, the highest indicator in the questionnaire results is indicator 1. In indicator 1, which is the presence of engaging activities in learning, the average score is 77, classified as very good. This condition is due to students experiencing a new way of learning, which involves using technology, including GeoGebra, to facilitate their understanding of the material. As a result, students are motivated to participate in the learning process. The second-highest indicator is indicator 4, which is the desire to succeed in learning, with an average score of 76, classified as very good. This is because students are motivated to learn collaboratively to solve problems together using the PjBL integrated STEM-GeoGebra model, resulting in a desire to succeed in their learning. The third-highest indicator is indicator 5, which is a conducive learning environment, with an average score of 75, classified as good. This is because students are more willing to ask questions to both peers and teachers when learning using the PjBL integrated STEM-GeoGebra model. This has a positive impact on increasing student engagement. Additionally, the implementation of the PjBL integrated STEM-GeoGebra model provides a new learning experience, motivating students to be directly involved in completing projects. The fourth-highest indicator is indicator 2, which is learner motivation and needs, with an average score of 74, classified as good. This is because the PjBL integrated STEM-GeoGebra model can motivate students to learn by utilizing technology and solving problems collaboratively in groups. The fifth-highest indicator is indicator 3, which is appreciation in learning, with an average score of 72, classified as good. This is because there is verbal appreciation and rewards from educators, leading to increased student engagement in learning.

Based on the analysis of the student response questionnaire results, it can be concluded that the PjBL integrated STEM-GeoGebra model can improve critical thinking skills, as supported by research by (Aini et al., 2022), which states that using project-based learning with a STEM approach can enhance students' critical thinking skills. The activities carried out in the PjBL integrated STEM learning model are oriented towards active student engagement, stimulating critical thinking. This aligns with the research by (Fadhilatunnisa et al., 2022), which states that the STEM learning model and the PjBL learning model are two types of learning models that can be utilized to enhance students' critical thinking skills. Moreover, integrating GeoGebra into the curriculum and learning approaches has been proven to be highly effective in various research studies in mathematics and STEM-related fields (Ziatdinov & Valles, 2022).

Findings in the field indicate that learning using the PjBL integrated STEM-GeoGebra model is not yet a common practice. The habits of conventional teaching methods in schools influence students' learning processes. In traditional learning, students only listen to what the educators convey without utilizing other learning resources. As a result, students may not be fully prepared, motivated, and inspired to learn when the PjBL integrated STEM model is implemented. Additionally, students may not be accustomed to solving story problems or answering questions based on critical thinking indicators, resulting in limited stimulation of their critical thinking skills. This aligns with the research by (Dewi, 2022), which states that the PjBL integrated STEM model requires more time in learning and focuses more on student activities, having a small impact on students' conceptual mastery.

CONCLUSION AND SUGGESTIONS

The application of the PjBL integrated STEM-GeoGebra model to improve mathematical critical thinking skills in mathematics learning, specifically on the topic of data usage for 7th-grade students at SMP Negeri 2 Surabaya, can be concluded that there is an improvement in critical thinking skills. This is evidenced by the average N-gain score of the pretest and posttest, which is 0.41, classified as a moderate category. The students' learning responses during the implementation of the PjBL integrated STEM-GeoGebra model are classified as good, with an average score of 75. The results of this research show that there is an improvement in critical thinking skills through the application of the PjBL integrated STEM-GeoGebra model in data usage topics, although the average improvement is small. This is because students are not accustomed to solving story problems and may not be familiar with answering questions according to critical thinking indicators, resulting in limited stimulation of their critical thinking skills.

The author provides several suggestions. It is recommended that educators should try to apply the PjBL integrated STEM-GeoGebra model in mathematics learning and other subjects because this research shows an improvement in critical thinking skills. Educators should also encourage students to practice solving story problems to stimulate their critical thinking abilities further. To the students, this research is expected to help improve their learning of data usage topics and motivate them to learn better. Other researchers are encouraged to conduct further studies on the PjBL integrated STEM model, using various learning media that incorporate STEM aspects, especially on data usage topics, for comparison with this research.

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