



Development of Problem-Based Student Worksheet Learning Media Using Geogebra to Improve Mathematical Reasoning Skills and Learning Independence

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Received: 18 Juli 2024 ; Accepted: 23 Agustus 2024 ; Published: 27 Agustus 2024

DOI: <http://dx.doi.org/10.15575/jp.v8i2.300>

Abstrak

Penelitian ini menguji keabsahan, kepraktisan, dan keberhasilan media pembelajaran LKPD berbasis masalah berbantuan geogebra dalam meningkatkan kemampuan berpikir matematis dan kemandirian belajar siswa. Penelitian ini menggunakan metode penelitian dan pengembangan. Model pengembangan yang digunakan adalah ADDIE. Penelitian ini melibatkan siswa kelas XI SMK salah satu SMK di Kabupaten Deli Serdang. Nilai rata-rata media pembelajaran Lembar Kerja Peserta Didik (LKPD) berbasis problem based learning berbantuan geogebra adalah 4,75 dengan kategori valid. Media LKPD berbasis problem based learning berbantuan geogebra dinyatakan praktis karena nilai rata-rata keterlaksanaan pembelajaran sebesar 87,22% berkategori baik dan respon siswa positif rata-rata 88,94% berkategori sangat positif. Nilai rata-rata ketuntasan klasikal siswa sebesar 93,75% berkategori sangat tinggi, rata-rata ketercapaian tujuan pembelajaran sebesar 89,06% dan rata-rata respon siswa sebesar 88,94% yang menunjukkan bahwa media LKPD berbasis problem based learning berbantuan geogebra efektif. Media yang dikembangkan dapat meningkatkan penalaran matematika dan kemandirian belajar siswa, ditunjukkan dengan nilai N-gain masing-masing sebesar 0,48 dan 0,55.

Kata Kunci: *Lembar Kerja Peserta Didik, Problem Based Learning, Kemampuan Penalaran Matematis, Kemandirian Belajar.*

Abstract

This research examined the validity, practicality, and efficacy of LKPD problem-based learning media with geogebra in promoting students' mathematical thinking and learning independence. Research and development are employed. ADDIE is this study's development model. This study involved class XI students of one of the vocational schools in Deli Serdang Regency. The average score for LKPD learning media based on problem-based learning helped by geogebra was 4.75 with a valid category. LKPD media based on problem-based learning assisted by geogebra is practical because the average score of learning implementation was 87.22%, which is good, and positive student responses averaged 88.94%, which is very positive. The average classical completeness value of students was 93.75% with a very high category, the average learning objective achievement was 89.06%, and the average student responses were 88.94%, indicating that LKPD media based on problem-based learning assisted by geogebra is effective. The developed media can improve students' mathematical reasoning and learning independence, as shown by their N-gain values of 0.48 and 0.55, respectively.

Keywords: *Student worksheets, problem-based learning, mathematical reasoning skills, learning independence.*

A. Introduction

Direct observation at Rokita Sari Bangun Purba Private Vocational School on mathematics teacher instruction. The instructor greets pupils at the start of the session. When the instructor enters the classroom and welcomes the pupils, the teacher does not smile or has a flat facial expression. After then, the instructor verifies each student's attendance. Then the instructor tells pupils to open their textbooks and announce the day's topics. The instructor randomly selects a student and takes turns reading the material so other students may hear it until it is done. In addition, the instructor writes the textbook title, definition, formula, and sample questions on the board to illustrate the content (Afif., A.M.S., 2016). The instructor finishes the example questions by asking pupils to focus on solving them. The instructor provides three sample questions to help pupils solve one subject. After explaining and showing instances, the instructor lets pupils ask questions if they don't understand. None of the pupils asked the instructor questions. The instructor then instructs pupils to access the content questions page in the book and complete the questions individually in class without a time restriction (Saniyyah, F., & Triyana, 2021).

The instructor stays in the classroom but periodically checks his phone while working on questions. Several pupils working on the teacher's questions were discreetly debating responses. This remained till lesson end. Then the instructor inquired whether the pupils were done, and they said no. The instructor made the questions homework to be collected at the following meeting (Yusdiana, B.I., dan Hidayat, 2018). These observations show that the instructor exclusively utilizes textbooks and whiteboards using the lecture approach, which bores pupils and demotivates them to study (Hasratuddin, 2018, Sobarningsih, N, 2019). Only sample and textbook questions are utilized by the instructor as recommendations and exams. This causes pupils to adopt the teacher's problem-solving strategy to solve material issues, preventing them from developing their mathematical reasoning abilities. Following class, the instructor was interviewed and found to have indicated that the school possessed projectors and laptops/computers (Kotto, M. A., Babys, U., dan Gella, 2022). Then the teacher explained that so far the students were able to complete the questions given as homework well, but when the written test was carried out directly, the students were unable to complete the questions given by the teacher. This can be proven from the students' answers in Figure 1.

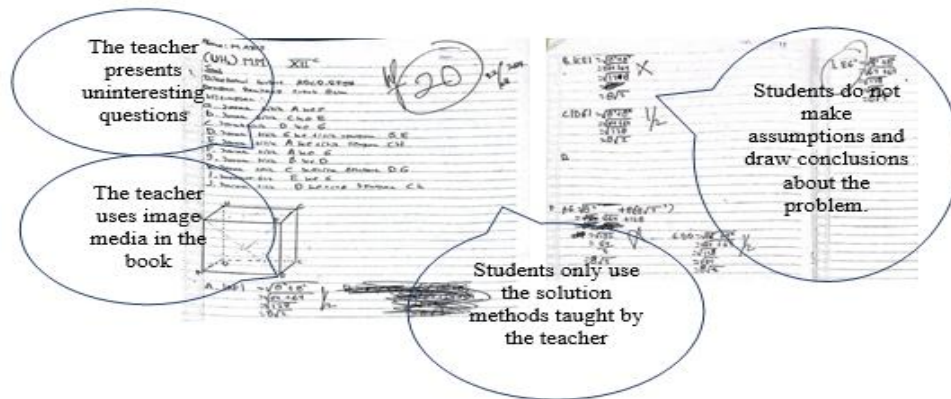


Figure 1. Answers of Class XI B Students

Based on Figure 1. The student's response shows that he cannot answer teacher-given test questions. Students forget the steps because they solve problems utilizing the teacher's way. Figure 1 shows that pupils cannot write conjectures or make conclusions. This demonstrates that kids have limited learning independence and quantitative thinking abilities. This shows that pupils who do schoolwork must cheat on wiser peers, ask relatives, etc. Learning independence is also crucial to classroom success. (Yamin, M. dan Ansari, 2008) said that autonomous pupils may overcome issues and hurdles. According to Setiawan (Siswono, 2018) learning independence is motivated by one's own will, choice, and responsibility for learning. Direct classroom observation revealed little student learning independence.

Some pupils solely listen to the instructor to learn, while others appear distracted. When working on the teacher's questions, numerous pupils discussed and asked peers for answers. Many scholars have worked to enhance Indonesian education. (Muruganantham, 2015) study on geogebra-based learning media with the ADDIE development model in class XI SMAN 3 Medan found that learning media may boost school learning. The validation of geogebra-based learning media, which received an average score of 4.2 from media experts and 4 from material experts, shows its high quality. The instructor response questionnaire scored 4.33 with Valid and the student response questionnaire 4.5 with Very Valid. This proves the learning medium is useful. Practicality of (Fauzan, 2018) learning media based on execution obtained an average score of 3.38 with a Very Good category. Thus, the learning mediums generated are practical. The effectiveness of the learning media was tested for 33 students and 1 mathematics teacher, and the student response was Positive with an average of 89% of all statement items in the Very Strong category, while the teacher's response was Positive with 92%. Student engagement averaged 3.55 in very active. learning outcome test with 100% classical completion. Geogebra-based learning medium is successful based on this evaluation.

Research to increase pupils' mathematical reasoning abilities solely involves Geogebra-assisted learning. Geogebra-assisted geometric transformation learning may increase students'

mathematical thinking, according to (Ridha, R. M., Dwipriyoko, E. dan Gumilar, 2020). According to (Lestari, 2018), using Geogebra on connection and function content improves students' mathematical thinking and learning independence.

Question: Are mathematical reasoning abilities not relevant for pupils today? Why not design instructional media that enhance mathematical reasoning? Learning medium must be tailored to students' requirements, and mathematical reasoning abilities are still essential in daily life. (Dewi Purnama Sari, 2018) define mathematical reasoning as the capacity to infer conclusions from mathematical data and believed connections. (Hidayati, K., dan Listyani, 2017, Joe, A. R, et all 2024) claimed mathematical reasoning is essential to issue solving and mathematics comprehension.

Based on the criteria above, students still require mathematical thinking to solve issues and form logical conclusions. Students must improve mathematical reasoning to build logical thinking in drawing conclusions and addressing difficulties in daily life. Learning models may be utilized to address difficulties because they encourage students to be active learners, which is crucial for student achievement. Problem-Based Learning (PBL) may push pupils to solve problems. According to (Kotto, M. A., Babys, U., dan Gella, 2022), the problem-based learning paradigm requires students to think, reason, communicate, seek for and interpret facts, and conclude. The instructor gives relevant and fascinating issues to help pupils to solve difficulties using reasoning in group discussions. Problem-based learning lets students express their critical thinking, reason, and share their work. Problem-based learning, according to (Alfiah, S., 2021), begins with contextual problems and is student-centered, builds understanding, and encourages discussion and question-and-answer activities. Problem-based learning is another way instructors may create an active learning environment.

The use of problem based learning models and the use of geogebra are expected to be a solution to improve students' mathematical reasoning skills and learning independence. Through the development of geogebra learning media using this problem based learning model, it is also expected that teachers or educators can create a more enjoyable and non-monotonous learning atmosphere so that students do not feel bored in following the learning process, so that students will find it easier to understand mathematics. Based on the description above, the researcher is interested in conducting research related to geogebra learning media, problem based learning models, students' mathematical reasoning skills, and students' learning independence entitled "Development of Mathematics Learning Media Based on Problem Based Learning Assisted by Geogebra to Improve Mathematical Reasoning Skills and Learning Independence of Class XI Students of SMK Swasta Rokita Sari Bangun Purba".

B. Research Method

Research and Development are used in this study. Research and Development is used to create a product and verify its validity, practicality, and efficacy before usage. This study

proposes redeveloping an existing product. The ADDIE development paradigm will be used in this study. The ADDIE approach develops geogebra learning media on Geometric Transformation and the essential research instruments via five steps: analysis, design, development, implementation, and assessment (Sugiyono, 2018). In the even semester of 2023/2024, SMK Swasta Rokita Sari Bangun Purba did this investigation on grade XI pupils. This study will be implemented April–May 2024. This research included 2023/2024 SMK Swasta Rokita Sari Bangun Purba class XI students. This research focuses on problem-based learning using geogebra on Geometric Transformation to promote students' mathematical thinking and learning independence.

C. Result and Discussion

Data analysis and research results obtained at each stage of development are presented as follows:

Analysis

The main learning media development issues were identified via student needs analysis. The researcher noticed arithmetic challenges in class XI of SMK Swasta Rokita Sari Bangun Purba. Based on early observations of learning media availability at SMK Swasta Rakita Sari Bangun Purba, mathematics learning media was underutilized. Students must utilize reasoning to grasp abstract and systematic mathematics. Unfortunately, teachers have not been able to produce engaging learning media to help pupils picture the subjects being studied. They only utilize blackboards and books. Students are more prone to remember and rely on instructor explanations than explore information and solve difficulties. Learning media should let students load and apply mathematical knowledge independently and build mathematical reasoning abilities.

Due to remembering and relying on teachers, pupils' limited mathematical reasoning abilities and learning independence are affected by the absence of mathematics learning media. Based on these issues, students' requirements for learning media tailored to their wants and desires are crucial to improving their mathematical reasoning and learning independence. Valid, practical, and successful mathematics learning media are needed to solve these issues. The produced learning media are intended to increase class XI students' mathematical thinking and learning independence at SMK Swasta Rokita Sari Bangun Purba.

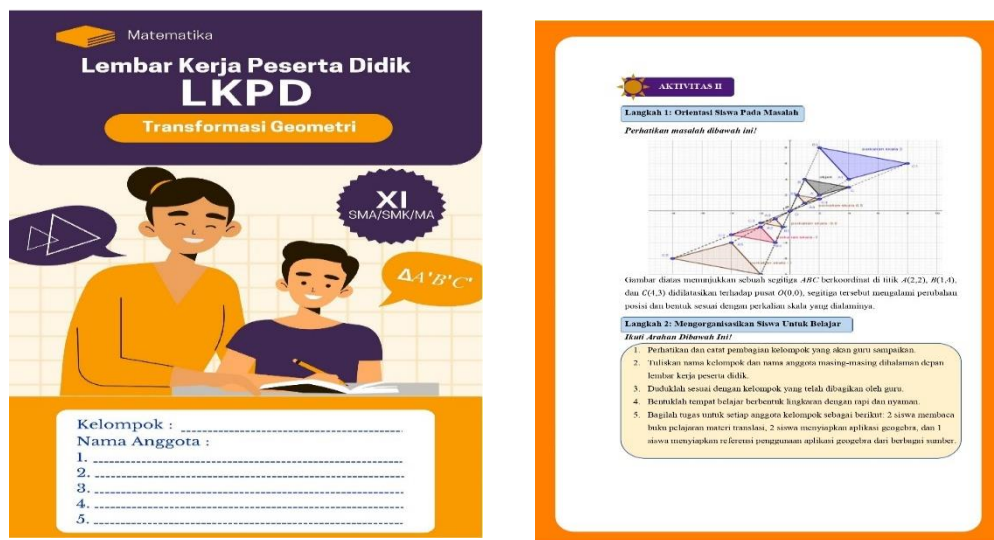
Design

This step designs learning media to create a geometric transformation material prototype. Two sets of student worksheets for two sessions. LKPD media uses geogebra to teach pupils problem-based learning assignments. Creating a Learning Implementation Plan (RPP) determines teaching and learning stages. A mathematical reasoning ability exam will be created from 2 translation and 2 dilation questions with Higher Order Thinking Skill questions. Each

translation and dilation mathematical reasoning exam question will include a picture to help students solve contextual concerns. First, the student learning independence questionnaire grid is created, which includes aspects of learning independence, achievement indicators, statement items, and total scores based on indicators.

Development

The creation of a product in the form of a student worksheet based on problem-based learning assisted by Geogebra is adjusted to the analysis and design stages. The product is designed using the Canva, Microsoft Word and Geogebra applications to produce images, graphics, and writing that are interesting and easy for students to understand. After the product is successfully created, the product is then tested to obtain valid, practical, and effective product



criteria. The following is a display of the student worksheet that was developed:

Figure 2. Student Worksheet Products

Table 1. Validation Results

No	Aspect	Average	Category
1	Learning Tool Plan	4,8	Valid
2	Student Worksheets	4,7	Valid
3	Mathematical Reasoning Ability	4,5	Valid
4	Learning Independence	4,5	Valid

Table 1 shows that the RPP, Student Worksheets have a total "valid" average of 4.5. The data in this study were analyzed using descriptive statistical analysis. According to Sheskin (2004), descriptive statistics as an analysis tool for the purpose of describing data without drawing conclusions and making predictions. Common procedures used in descriptive statistics are in the form of tables, graphs, diagrams and calculations on the size of the central and dispersion of data.

Implementation

Results of Analysis of Students' Mathematical Reasoning Ability Tests in Trials

In the trial, the level of student mastery is reviewed from the mathematical reasoning ability using a mathematical reasoning ability test. The description of the results of the mathematical reasoning ability test is shown in the following table:

Table 2 Description of the Results of Mathematical Reasoning Ability in the Trial

	Value Interval	Trial Class		Category
		The number of students	Percentage	
1	$90 \leq \text{KPM} \leq 100$	5	12,5%	Very High
2	$80 \leq \text{KPM} < 90$	17	53,13%	High
3	$70 \leq \text{KPM} < 80$	7	21,88%	Fair
4	$60 \leq \text{KPM} < 70$	3	9,38%	Low
5	$0 \leq \text{KPM} < 60$	0	0%	Very Low

Based on table 2, it shows that in the trial, the results obtained were that 5 students (12.5%) had a level of mastery of mathematical reasoning ability in the very high category, 17 students (53.13%) had a level of mastery of mathematical reasoning ability in the high category, 7 students (21.88%) had a level of mastery of mathematical reasoning ability in the sufficient category, 3 students (9.38%) had a level of mastery of mathematical reasoning ability in the low category, while the level of mastery of mathematical reasoning ability in the very low category was 0 students (0%).

Analysis of Student Learning Independence Results in Trial

The student learning independence questionnaire was used to see the extent to which the aspects of free responsibility, progressive and persistent, initiative or creative, self-control, and self-stability of students in understanding the components of media and learning devices developed through the problem-based learning model assisted by geogebra. The student learning independence questionnaire had positive and negative responses including 15 positive statements and 15 negative statements. Based on the results of the analysis of the student response questionnaire, it shows that the average percentage of positive student responses to the student learning independence questionnaire can be seen in the following table 3:

Table 3. Results of the Student Learning Independence Questionnaire in the Trial

Interval	Category	Trial Class	
		The number of students	Percentage
76-100	Very Good	9	28,12%
51-75	Good	20	62,50%
26-50	Quite Good	3	9,28%

0-25	Not Good	0	0%
Total		32	100%

Based on table 3, it shows that after being given treatment, 9 students (28.12%) obtained the very good category, 20 students (62.50%) obtained the good category, 3 students (9.28%) obtained the fairly good category and 0 students (0%) obtained the less good category.

Results of Mathematical Reasoning Ability Test Analysis

In this study, the level of student mastery is reviewed from the mathematical reasoning ability using a mathematical reasoning ability test. This study used a pretest and posttest to class XI A totaling 32 students to see the improvement of mathematical reasoning ability. Furthermore, the level of mastery of mathematical reasoning skills in the implementation results can be seen in table 4 below.:

Table 4 Level of Mastery of Mathematical Reasoning Ability

No	Value Interval	Pretest		Posttest		Category
		The number of students	Percentage	Percentage		
1	$90 \leq KPM \leq 100$	0	0%	Very High	31,25%	Very High
2	$80 \leq KPM < 90$	10	31,25%	High	62,50%	High
3	$70 \leq KPM < 80$	7	21,88%	Fair	0%	Fair
4	$60 \leq KPM < 70$	13	40,63%	Low	6,25%	Low
5	$0 \leq KPM < 60$	2	6,25%	Very Low	0%	Very Low

Table 4 shows that in the pretest of 32 students, no students had mathematical reasoning abilities in the very high category (0%), 10 students (31.25%) had high mastery, 7 students (21.88%) had sufficient mastery, 13 students (40.63%) had low mastery, and 2 students (6.25%) had very low mastery. In the posttest after learning using PBL-based LKPD media assisted by geogebra, 10 students (31.25%) had very high mastery, 20 students (62.50%) had high mastery, 0 students (0%) had sufficient mastery, 2 students (6.25%) had low mastery, and no students (0%) had t mastery.

Analysis of Student Learning Independence Results

The student learning independence questionnaire was used to see the extent to which the aspects of free responsibility, progressive and persistent, initiative or creative, self-control, and self-stability of students in understanding the components of media and learning devices developed through the problem-based learning model assisted by geogebra. The student learning independence questionnaire had positive and negative responses including 15 positive

statements and 15 negative statements. Based on the results of the analysis of the student response questionnaire, it shows that the average percentage of positive student responses to the student learning independence questionnaire can be seen in the following table 5

Table 5. Results of Student Learning Independence Questionnaire

Interval	Category	Pretest		Posttest	
		The number of students	Percentage	The number of students	Percentage
76-100	Very Good	1	3,12%	18	56,25%
51-75	Good	18	56,25%	12	37,50%
26-50	Quite Good	13	40,63%	2	6,25%
0-25	Not Good	0	0%	0	0%
Total		32	100%	32	100%

Based on table 5, it shows that before being given treatment, students who obtained the very good category were 1 student (3.12%), students who obtained the good category were 18 students (56.25%), for the fairly good category were 13 students (40.63%) and for the less good category were 0 students (0%). While after being given treatment, students who obtained the very good category were 18 students (56.25%), students who obtained the good category were 12 students (37.50%), for the fairly good category were 2 students (6.25%) and the less good category were 0 students (0%).

Evaluation

After media development, 5 validators—3 lecturers and 2 teachers—tested its validity. The five validators added captions to media and reasoning ability test images, expanded the LKPD answer space to allow students to express their thoughts, and directed the language on the learning independence questionnaire. The fifth validator suggested some changes, but the product is legitimate.

The produced medium was also examined for practicality and efficacy at the implementation stage, and it satisfied the requirements. Based on testing findings, the researcher implemented numerous media modifications to maximize outcomes. The implementation findings demonstrated that the designed medium was valid, effective, and practical and improved students' thinking and learning independence. Class XII A also tested the mathematical reasoning ability exam and learning independence questionnaire for validity and reliability. Thus, 4 essay questions of reasoning ability and 30 statements of learning independence surveys were valid, reliable, and suitable for study. At the testing stage, the mathematical reasoning ability test and learning independence questionnaire were recommended to be given in classes that had previously learned the same material, so students would not have trouble answering the instrument.

Discussion

The LKPD media based on problem based learning assisted by geogebra that was developed is said to be effective if: (1) Learning is said to be complete if there are at least 85% of students who take the test have mathematical reasoning skills in the moderate category. (2) Achievement of learning objectives. (3) Student learning independence during learning is in the positive category. (4) At least 80% of the many students and subjects studied (for each test) gave a positive response to the learning media and learning activities. Based on the results obtained from the implementation test on class XI A students, the results of the effectiveness of LKPD based on problem based learning assisted by geogebra include: there are 30 (93.75%) of 32 students who have taken part in learning using the developed media who are declared successful classically with very high and high value categories or can be said to be complete. The results of this study are greater than the relevant research of Suryawan and Permana, D. (2020) regarding the development of online learning media based on geogebra as an effort to improve understanding of mathematical concepts with a completion score of 93.33%, research by (Rangkuti, 2023) regarding the development of mathematics learning media assisted by geogebra to improve students' mathematical concept understanding abilities with a score of 80%, and research by Anggraeni, E.R., Ma'rufi, and Suaedi (2021) regarding the development of mathematics learning media based on geogebra to improve students' conceptual understanding abilities with a completion score of 81.81%. The achievement of the learning objectives of this study at the first meeting was 84.73% and at the second meeting was 88.02% with an average achievement of learning objectives of 86.37% which means that the learning objectives have been achieved well. Student learning independence was obtained based on the results of the student learning independence questionnaire analysis which showed that 18 students were in the very good category, 12 students were in the good category, 2 students were in the fairly good category, and no students were in the poor category.

The results of the student response questionnaire showed that students gave a positive response to the learning media and learning activities with an average score of 88.94%. This result is lower than the relevant research of (Anggraeni, E.R., Ma'rufi, 2021) regarding the development of geogebra-based mathematics learning media to improve students' conceptual understanding abilities with a score of 94.27% of students responding positively. This can happen because there are differences in the needs and conditions of the students studied so that students can give different responses to the media developed. Based on the findings above, it can be concluded that the LKPD media based on problem-based learning assisted by geogebra that has been developed has met the criteria for effectiveness..

D. Conclusion

Based on the research and debate in this study, we may conclude: Valid, practical, and successful LKPD media uses problem-based learning and geogebra to improve students' mathematical thinking and learning independence. Media development validity averaged 4.75.

The practicality of the medium generated scored 87.22% for learning application and 88.94% for good student reactions. The media developed was effective as shown by students' classical completeness of 93.75%, learning objectives achieved of 86.37%, and student learning independence measured by 18 very good, 12 good, and 2 fairly good students. Student reaction questionnaire scores averaged 88.94% positive. Students that received problem-based learning media with geogebra showed a modest improvement in mathematical reasoning with an N-gain value of 0.48. Ten students scored high, 7 scored adequate, and 13 scored poor on the pretest and posttest for mathematical thinking. In the posttest, 10 students scored extremely high, 20 high, and 2 low. The N-gain value of 0.55 showed a modest improvement in learning independence for students treated with problem-based learning media and geogebra. In the pretest, 1 student had very excellent learning independence, 18 had good, 13 had pretty good, and 0 had less good. In the posttest, 18 students had very excellent learning independence, 12 good, 2 pretty good, and no less good.

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