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Development of Geogebra-Assisted Learning Tools to Improve Students' Mathematical Communication Skills and Learning Motivation

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Abstract

This study aims to produce GeoGebra-assisted learning tools to improve students' mathematical communication skills and learning motivation in terms of validity, practicality, and effectiveness. The research model uses the ADDIE model, namely analysis, design, development, implementation, and evaluation. The subjects of this study were students of class IX E MTs Negeri 9 Bantul. The research instruments used consisted of validation sheets, practicality assessment sheets by teachers and students, observation sheets for learning implementation, mathematical communication ability test questions and learning motivation questionnaires. Validity and practicality data analysis was carried out by converting quantitative data into qualitative forms on a five-point scale. Effectiveness data analysis was carried out using Paired sample t-test and one sample t-test. Based on the data analysis, it is known that the GeoGebra-assisted learning device developed meets the valid aspects with the criteria of "Good", then the practicality test developed by the teacher's assessment of the teaching module with the criteria of very "Good", the student's assessment of the LKPD with the criteria of "Good", and the results of the implementation of learning are assessed with an average percentage of more than 85%. The effectiveness of the mathematics learning device developed with the criteria of effective based on the percentage of student learning completion in the post-test of communication skills is more than 75%. It can be concluded that there is a significant increase between the results of the pre-test and post-test of communication skills and student learning motivation.

Keywords: *Development; Geogebra; Mathematical Communication; Learning Motivation*

Introduction

Mathematics is one of the most important subjects in human life. Without mathematical knowledge, nothing can be said to be possible in this world. Mathematics is a body of knowledge in the fields of science and technology (Acharya, 2017). Mathematics is a beautiful and interesting subject because it has symbols, language, terms, technology. The objectives of mathematics learning stated in the 2013 curriculum prepare Indonesians to have the ability to live as individuals and citizens who are faithful, productive, creative, innovative and affective and able to contribute to the life of society, nation, state, and world civilization (Aprilia, 2022). Mathematics is one of the subjects that is the main material at various levels of education. Mathematics learning does not only discuss calculations, but also trains students' communication skills (Fauzan & Suhandri, 2023).

Mathematical communication skills are the core ability to communicate about mathematical elements or statements, including mathematical facts, concepts, principles, and procedures through explanations, writing, or discussions of words that are not understandable. Mathematical communication skills include the ability to explain, formulate arguments, interpret, connect, construct mathematical ideas or concepts into mathematical language or symbols, make predictions, formulate definitions, statements, and mathematical generalizations (Salsabila, 2019).

Students' mathematical communication skills are still considered low or lacking in Indonesia. One reason for this is the tendency of current learning models to be one-way, focusing on the teacher (Rahmawati et al., 2023). Communication skills in mathematics learning in junior high schools receive little attention from teachers. This is because teachers still tend to be active, using a lecture-based approach to delivering material to students. Consequently, students' mathematical communication skills are weak. Students are less able to communicate their mathematical ideas clearly and correctly, both verbally and in writing. Therefore, a good learning system is needed to produce high-quality learning (Wijayanto et al., 2018). In the field, reality emphasizes that students' mathematical communication skills are still low and they are not able to solve mathematical communication problems, even though this ability is one of the abilities that students must have (Nursalam et al., 2020).

In addition to students' mathematical communication skills, low internal and external motivations contribute to a lack of enthusiasm for mathematics learning. Mathematics learning is still not enjoyable for all students. Many students still consider mathematics a difficult subject. To create mathematics learning activities that motivate students to actively participate, appropriate learning strategies are needed (Noor et al., 2018). Although student motivation plays a significant role in the mathematics learning proces many students remain unmotivated. Motivation is a person's state in the form of encouragement or enthusiasm in carrying out an activity to achieve a goal (Effendi et al., 2023).

Based on observations at MTs Negeri 9 Bantul, information was obtained that students have not received guidance on the use of Teaching Modules and LKPD assisted by GeoGebra. The learning tools used by educators are varied but are still limited to printed books and student worksheets. Consequently, low mathematical communication skills and student learning motivation are a situation where a quarter of students often talk during direct lessons, students are less enthusiastic and tend to be inactive in participating in the learning process. This seems to have a negative impact on mathematics learning outcomes, with the majority of students still below the minimum completion criteria of 70.

To improve communication skills and learning motivation, learning tools such as teaching modules and student worksheets (LKPD) can be used. Teaching modules are one of the teaching tools used in the Independent Curriculum (Curriculum Merdeka) in the learning process. A teaching module is a document containing the objectives, steps, and learning media, as well as the assessments required for a unit based on the Learning Objectives Flow (ATP) (kemendikbud, 2022). Creating teaching modules is a pedagogical competency of teachers that needs to be developed, this is so that teachers' teaching techniques in the classroom are more effective, efficient, and do not deviate from the discussion of achievement indicators (Maulida, 2022). Student worksheets (LKPD) can facilitate teachers in implementing the learning process. Furthermore, LKPD are rich in practice assignments (Astuti, 2021).

The use of learning media is expected to encourage students to improve their mathematical communication skills and learning motivation. One solution to this is to choose technology-based learning media, including GeoGebra. The rapid development of technology opens up new opportunities and avenues for many things. The application of technology, especially software or computer programs, to teach mathematics in schools is one option for new learning media, particularly mathematics. One program used in geometry learning is GeoGebra software (Aprilia, 2022). GeoGebra was developed by Markus Hohenwarter in 2001. GeoGebra is a computer program that teaches mathematics, particularly geometry and algebra. GeoGebra software can be used as a tool for constructing mathematical concepts.

This research aims to develop learning tools in the form of teaching modules and assisted student worksheets (LKPD). The developed learning tools must be suitable for use in school learning. These learning tools will be used to develop the mathematical communication skills and learning motivation of junior high school students in Indonesia in general and in Yogyakarta in particular.

Method

The method used in this research is the research and development (R & D) method to produce a particular product, and test the effectiveness of the product (Sugiyono, 2000). The research development model used in this development research is the ADDIE development model. This development model includes 5 stages, namely (1) Analysis, (2) Design, (3) Development, (4) Implementation, (5) Evaluation. The data obtained in this research consists of qualitative and quantitative data. The average score achieved in this research is in the "sufficient" criteria if the minimum average score is more than 60% of the maximum score for each assessment sheet Sedarmayanti & Hidayat (2011).

Table 1. Conversion of Quantitative Data to Qualitative Data

Interval	Categoris
$X > A + 2B$	Very high
$A + B < X \leq A + 2B$	High
$A < X \leq A + B$	Medium
$A - C < X \leq A$	Low
$X \leq A - C$	Very low

a. Qualitative data analysis

Qualitative data, such as suggestions from validators, teachers, supervisors, and students. This data is analyzed by researchers and used to refine the product.

b. Quantitative data analysis

Quantitative data were obtained from scores given by the validator, teacher and student assessment scores for the developed teaching modules and student worksheets (LKPD), learning implementation scores, pretest and posttest scores for mathematical communication skills, and student learning motivation. The quantitative data analyzed included (1) the validity of the teaching modules and LKPD, (2) the practicality of using the teaching modules and LKPD, and (3) the effectiveness of using the teaching materials and LKPD. The quantitative data obtained were converted into qualitative data.

GeoGebra-assisted PBL learning devices are said to be valid and practical if they meet the minimum criteria both from the validation results of material experts and media experts, teacher and student practicality assessment questionnaires, and learning implementation observation sheet questionnaires. Furthermore, the effectiveness of GeoGebra-assisted PBL learning devices is carried out using Paired sample t-test and one sample t-test using Rstudio.

First Test Hypothesis and Questionnaire

H_0: $\mu_d \leq 0$: There was no increase in pretest and posttest scores of mathematical communication skills.
H_1: $\mu_d > 0$: There was an increase in pretest and posttest scores of mathematical communication skills
H_0: $\mu_d \leq 0$: There was no increase in pretest and posttest scores of students' learning motivation.
H_1: $\mu_d > 0$: There was an increase in the pretest and posttest scores of students' learning motivation.
Significant level $\alpha = 0,05$
Test Statistics: *Paired Sample t-test*
Hypothetical decision criteria: *p-value* < α =*0,05* if , then H_0 Rejected

Second Test Hypothesis and Questionnaire

$H0 = \mu \leq 75$: The average score of the mathematical communication ability pottest is less than or equal to 75
$H0 = \mu > 75$: The average score of the mathematical communication ability pottest is over 75
$H0 = \mu \leq 110$: The average score of the student learning motivation pottest is less than or equal to 110
$H0 = \mu > 110$: The average score of the student learning motivation pottest is more than 110
Significant level $\alpha = 0,05$
Test Statistics: one sample t-test.
Hypothetical decision criteria: H0 rejected if tcount > $t\alpha$ (n-1) or if p-value < α

Result and Discussion

The learning tools developed in this study are teaching materials in the form of LKPD assisted by GeoGebra on the material of flat-sided solid shapes for class IX E students at MTs Negeri 9 Bantul developed by Dick & Carey (1996: 2-3) using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation), including the following.

1. Analysis

At this stage, the first step is a needs analysis, where researchers conduct observations and interviews to ensure the needs for designing learning tools, such as teaching modules and student worksheets, are good and appropriate for the learning situation. Then, a student characteristics analysis is conducted, where class IX E students at MTs Negeri 9 Bantul have different characteristics. Next, a material analysis is carried out to provide information regarding the delivery of material, competencies, learning objectives, and evaluations to be carried out. The curriculum implemented at the school is the independent curriculum. The material used is flat-sided geometric shapes.

2. Design

At this stage, it consists of compiling teaching modules and designing LKPD. The teaching modules developed consist of several parts, namely, (1) Identity of the teaching module (Name of compiler, institution, and year of compilation of the teaching module, School level (elementary/middle/high school), class/semester, main material, and time allocation), (2) Initial competencies, (4) Pancasila profile, (5) Facilities and infrastructure, (6) Target students, (7) Learning model, (8) Learning objectives, (9) Meaningful understanding, (10) Initiating questions, (11) Learning activities, (12) Assessment. The LKPD design is made in accordance with the learning outcomes and sub-learning outcomes as well as the design of the Teaching Module that is made. In general, the LKPD design consists of five components. (Rahimah, 2022). According to Kamalia (2009: 32) The design of the LKPD components is as follows: 1) LKPD title, (2) Student identity, (3) Learning objectives, (4) Instructions for use, (5) Student activities. At this stage, in addition to compiling teaching modules and

LKPD, research instruments are also designed, namely a mathematical communication ability test and a student learning motivation questionnaire.

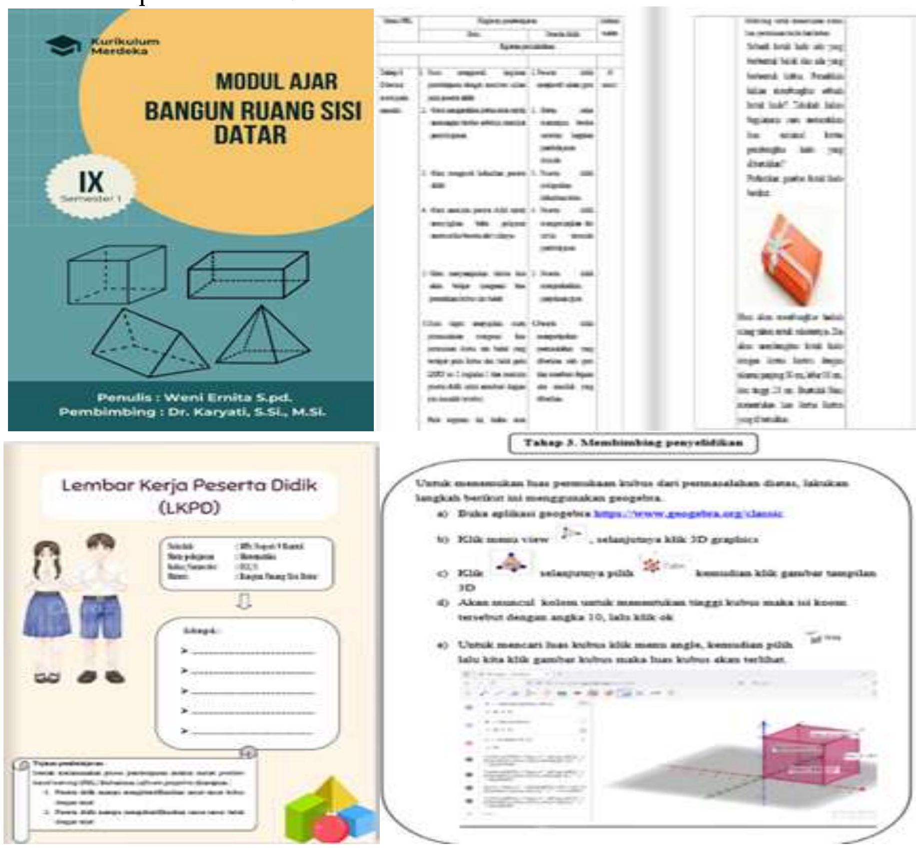

Figure 1. Teaching Modules and LKPD assisted by GeoGebra

3. Development

After designing the product, the researcher conducted the product development stage. The researcher then developed the learning materials, including a teaching module and student worksheets (LKPD), as well as instruments for testing mathematical communication skills and a questionnaire on students' mathematical learning motivation. The learning materials developed with the assistance and guidance of the supervisor were then validated by two validators. The results of the developed learning materials were then validated by the validators. A summary of the material validation results is presented in the table below.

Table 2. Results of the validity analysis of the Teaching Module for each aspect

	Validation score for each aspect		Amount
	Content aspect	Language Aspects	
Expert 1	139	12	151
Expert 2	136	12	148
	Average		149,5
	Category		Valid

Table 3. Results of the Analysis of the Validity of LKPD for Each Aspect

	Validation score for each aspect		Amount
	Content aspect	Technical Aspects	
Expert 1	65	48	113
Expert 2	64	46	110
	Average		111,5
	Category		Valid

The validation results show that the Teaching Module and Student Worksheet (LKPD) were categorized as valid. Therefore, the developed learning tools meet the criteria for being suitable for testing in learning activities. Furthermore, based on the assessment results of each validator, the mathematics communication skills test and student learning motivation questionnaire were categorized as good, meaning the developed mathematics learning motivation questionnaire is valid with several revisions made as suggested.

4. Implementation

At this stage, several activities were carried out, namely: This limited trial aimed to measure the reliability of the mathematical communication ability test instrument and the student learning motivation questionnaire using Alpha Cronbach with the help of SPSS. An instrument is said to be reliable if its minimum reliability coefficient is 0.65 (Ebel & Frisbic, 1991, p. 86). Based on the results, this limited trial was conducted on 30 students of MTs Negeri 9 Bantul.

The large field trial was conducted over 8 meetings and was attended by 32 class IX/E MTs Negeri 9 Bantul where learning using the Teaching Module and LKPD was conducted over 6 meetings and the first meeting was allocated to conduct a pretest on mathematical communication skills, then the 8th meeting was allocated to conduct a posttest on mathematical communication skills, filling out a learning motivation questionnaire and lifting the students' practicality test. During the learning process, from the first to the sixth meeting, observations and assessments were conducted by observers to assess the practicality of the learning tools. Data were obtained from the practicality assessment sheet provided by the mandatory mathematics teacher, student response sheets, and the implementation of the learning. Effectiveness data was obtained from the results of the mathematics communication skills test and the student learning motivation questionnaire.

The researcher conducted learning implementation activities at each meeting using observation sheets developed based on the Teaching Module and Student Worksheets (LKPD) systematically. Based on the percentage, learning implementation, both teacher and student activities, reached 100%, with a very practical category, as evidenced by the minimum achievement data of 85%.

Based on the observation data, the implementation of learning is stated to be in the very good category, which means that the observation data on the implementation of the learning developed is very practical with several revisions that have been improved according to suggestions.

The developed devices were then filled out by teachers to determine whether the devices we created were practical for use in schools. The following table shows the results of the teacher's assessment of the learning devices.

Table 4. Results of Practicality Analysis Based on Teacher Assessment

No	Device	Score
1	Teaching Module	35
2	Student Worksheets (LKPD)	46
3	Implementation of Learning	25
Total	108	
Category	Very High	

Based on the table above, the practicality assessment carried out by the teacher shows that the learning devices in the form of Teaching Modules and LKPD received a score of 108 out of 125 and are in the very practical category with input and suggestions that it is necessary to pay attention to students who are still less interested in learning.

Table 5. Practical Results Based on Student Assessment

Many Students	percentage	Score (X)	Category
6	20,81%	X > 65	Very Practical
26	79,19%	55< X ≤ 65	Practical
0	0	45 < X ≤ 55	Medium
0	0	30< X ≤ 45	Less Practical
0	0	X ≤ 30	Very Less Practical
Average		59, 2	Practical

Based on the table above, the practicality assessment of the LKPD carried out by 32 was carried out after the learning process at the last meeting. It can be concluded that the learning device is included in the "practical" category with an average of 59,2.

The effectiveness of this learning tool was assessed by analyzing the results of pretests and posttests that measured students' mathematical communication skills. This evaluation process aimed to assess the extent of improvement in students' mathematical communication skills before and after using the learning tool. Based on the results of the learning device with the material of flat-sided solid shapes developed for grade IX MTs students, it shows that the percentage of student learning completion in the post-test results of mathematical communication skills reached 93.75%, which means more than 75% with the KKM of 70 (school KKM). In addition, there was an increase in the average score of students' mathematical communication skills after using the learning device in the form of Teaching Modules and LKPD, where the average post-test score of mathematical communication skills was higher than the average pre-test score meeting the effective criteria.

Next, a hypothesis test will be conducted to determine whether there is a significant difference between the mathematical communication skills in the pretest and posttest results. However, before that, an assumption test will be conducted, namely a normality test for the mathematical communication skills test using the Shapiro-Wilk method with the help of the R Studio software application.

Table 6. Normality Test of Pretest and Posttest of Mathematical Communication Ability

Aspect	Sig.
Pretest Results	0,073
Posttest Results	0,053

Based on the results of the Shapiro-Wilk test, the significance value of the pretest and posttest H_0 was accepted. Thus, at a significance level of more than $\alpha = 0.05$, it can be concluded that the pretest and posttest scores of mathematical communication ability are normally distributed. Hypothesis testing was conducted using the Paired Sample T-Test and One Sample T-Test test statistics with the help of the R studio software application.

First Hypothesis of Mathematical Communication Ability

Table 7. Paired Sample T-Test Results for Mathematical Communication Ability Test

Aspect	Sig. (2-tailed)
Pretest and posttest results	p-value < $2{,}2 \times 10^{-16}$

Based on the results of the Paired Sample T-Test for the mathematical communication ability test, a significance value of p-value $<2.2 \times 10^{-16}$ (≈0.000) was obtained which was less than α=0.05 and t was positive. This means that H_0 is rejected, so it can be concluded that there is a significant increase between the pretest and posttest results in mathematical communication ability.

Second Hypothesis of Mathematical Communication Ability

Table 8. Results of the One Sample T-Test for the Mathematical Communication Ability Posttest

Aspect	Sig. (2-tailed)
Posttest of Mathematical Communication Ability Test	p-value = 0,0001112

Based on the results of the one Sample T-Test for the posttest of mathematical communication ability, a significance value of p-value = 0.0001112 (≈0.000) was obtained which was less than $\alpha = 0.05$ and t was positive. This means that H_0 is rejected, so it can be concluded that there is an average posttest score of mathematical communication ability of more than 75. Thus, the learning device in the form of Teaching Modules and LKPD assisted by GeoGebra is effective in improving students' mathematical communication abilities.

Further effectiveness is seen from the results of the learning motivation questionnaire. Based on the results of the percentage of student learning motivation after learning using the Teaching Module and LKPD, which has a high and very high category reaching more than 75%, there is also an increase in student learning motivation after using the GeoGebra learning device. This increase is indicated by a higher average learning motivation score after using the GeoGebra learning device compared to the average learning motivation score before using the device. These results indicate that the GeoGebra learning device meets the criteria for effectiveness when viewed from the aspect of student learning motivation.

Next, a hypothesis test will be conducted to determine whether there is a significant difference between students' learning motivation in the pretest and posttest results. However, before the hypothesis test is conducted, an assumption test will first be conducted, namely a normality test for the student learning motivation questionnaire using the Shapiro-Wilk method with the help of the R Studio software application.

Table 9. Normality Test of Pretest and Posttest of Learning Motivation Questionnaire

Aspect	Sig.
Pretest Results	0,053
Posttest Results	0,117

Based on the results of the Shapiro-Wilk test, the significance value of the pretest and posttest H_0 was accepted. Thus, at a significance level of more than $\alpha = 0.05$, it can be concluded that the pretest and posttest values of student learning motivation are normally distributed. Hypothesis testing was carried out using Paired Sample T-Test and One Sample T-Test test statistics with the help of the R studio software application.

First Hypothesis of Student Learning Motivation

Table 10. Paired Sample T-Test Results for the Learning Motivation Questionnaire

Aspect	Sig. (2-tailed)
Pretest and posttest results	p-value = $2{,}215 \times 10^{-11}$

Based on the results of the Paired Sample T-Test for the learning motivation questionnaire, a significance value of p-value = 2.215×10^{-11} (≈0.000) was obtained which was less than $\alpha=0.05$ and t was positive. This means that H_0 is rejected, so it can be concluded that there is a significant increase between the pretest and posttest results on the student learning motivation questionnaire. Thus, the learning tools in the form of Teaching Modules and LKPD assisted by GeoGebra are effective in increasing student learning motivation.

Second Hypothesis of Student Learning Motivation

Table 11. One Sample T-test Results for the Learning Motivation Questionnaire Posttest

Aspect	Sig. (2-tailed)
Posttest of the Learning Motivation Questionnaire	p-value = $6{,}752 \times 10^{-14}$

Based on the results of the one Sample T-Test for the posttest of learning motivation, a significance value of p-value = 6.75×10^{-14} (≈ 0.000) was obtained which was less than $\alpha=0.05$ and t was positive. This means that H_0 is rejected, so it can be concluded that there is an average posttest score of student learning motivation of more than 110. Thus, the learning device in the form of a Teaching Module and LKPD based on Problem Based Learning assisted by GeoGebra is effective in increasing student learning motivation.

5. Evaluation

The results of the study indicate that the needs required for the learning process in students vary depending on the characteristics of the students, this can be seen from the results of the analysis conducted by the researcher. Next, the researcher compiled teaching modules and LKPD according to the needs. In addition to compiling teaching modules and LKPD, they also designed research instruments, namely a mathematical communication ability test and a student learning motivation questionnaire according to the indicators. Thus, the development of learning tools in the form of teaching modules and LKPD assisted by GeoGebra can improve students' mathematical communication abilities and learning motivation Inaddition, the teaching module and LKPD and the teaching module developed meet the valid aspects as seen from validation by two validators. Practical can be seen from the results of the practicality assessment by teachers and students as well as the learning implementation sheet and effectiveness can be seen from the results of the mathematical communication ability test and student learning motivation. Syahril et al. (2023) explained that the developed teaching materials meet the valid and practical criteria for use in the learning process. The resulting learning device meets Nieveen's criteria of validity, practicality, and effectiveness. Therefore, the product can be used as an aid in mathematics learning.

Conclusion

Based on the formulation of the problem and the development objectives in this study, it was concluded that (1) the developed GeoGebra-assisted teaching module and LKPD met the valid aspects with the criteria of "Good", (2) the developed GeoGebra-assisted teaching module and LKPD met the practicality test with a score of 108 in the very good category, the students' assessment of the LKPD obtained an average score of 59.2 in the good category, and the results of the learning implementation were assessed with an average percentage of more than 85%. (3) The developed GeoGebra-assisted teaching module and LKPD met the effective aspects where the results of the mathematical communication ability test and students' learning motivation were analyzed using the Paired Sample t-test and one sample t-test. Based on the percentage of students' learning completion in the post-test of communication ability and learning motivation, it was more than 75%. It can be concluded that there was a significant increase between the results of the pre-test and post-test of students' communication ability and learning motivation.

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