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Communication skills and mathematical disposition in implementing geogebra-assisted problem-based learning strategies

Christina Khaidir[1*], Rozi Fitriza[2], Ninik Yumariza[3], Rahmatul Wahid[4]
[1*,2,3,4]Tadris Matematika, Universitas Islam Negeri (UIN) Imam Bonjol , Sumatera Barat 25153, Indonesia
[1*]christinakhaidir@uinib.ac.id, [2]rozifitriza@uinib.ac.id, [3]ninikyumariza1103@gmail.com, [4]rahmatulwahid5@gmail.com

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*Corresponding author

***Abstract*:**
This paper aims to determine students' communication skills and mathematical disposition in implementing problem-based learning strategies using the Geogebra application. This type of research was a quasi-experiment with a control group design. The subjects of this research were classes A and B. The population in this research was all students in the odd semester 2023/2024 who were taking the Plane and Space Geometry course, which consists of two classes that were tested using the t-test with data from the student's final test. Based on calculations of the results of students' mathematical communication skills, specifically the experimental class 81.00 and the control class 71.16. Thus, students' mathematical communication abilities in problem-based learning assisted by Geogebra were better than those in conventional education. On the other hand, the results of students' mathematical disposition abilities were 76.59 for the experimental class and 68.16 for the control class. Thus, students' mathematical disposition abilities in problem-based learning assisted by Geogebra were better than those in conventional education.

Keywords: Communication Skills; Implementing Geogebra-Assisted; Mathematical Disposition; Problem-Based Learning.

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Introduction

A well-rounded education should include a solid foundation in mathematics, a universal science relevant in many fields. Mathematics is considered compulsory in elementary, middle, and high schools in Indonesia and in the country's specialized technical and vocational institutions (Tanjung et al., 2023). Science and technology, which develop rapidly every year, require every actor to update their knowledge to create competitive changes continuously. Some actors who have contributed to the

development of science and technology are practitioners, especially in education. As a science, an essential part of the world of education, mathematics plays a role in almost every element of life (Lundin, 2012). Mathematics needs to be taught because it is a vital, short, and explicit means of communication.

Nalman and Susanta (2023), Mathematics is the science of logic regarding shape, arrangement, quantity, and concepts that are related to one another. Learning mathematics has the potential to develop thinking skills, the ability to argue creatively, and skills in solving problems, which can then be used to communicate and elaborate on the ideas obtained (Yumariza et al., 2023). Communication skills are one of the basic abilities that must be mastered in mathematics (Wahid et al., 2023). Communicating ideas and opinions will be increasingly needed, in line with increasingly solid demands for openness and accountability from each institution (Eliza, 2016). Communication skills are one of the basic abilities that must be mastered in mathematics (Wahid et al., 2023). In line with this, Rismawati stated that mathematics learning emphasizes mastery of concepts so that students have good basic concepts to achieve other abilities such as communication, connections, reasoning and problem-solving (Rismawati, M., & Hutagaol, 2018).

Based on Hamzah (2014), There are five areas (systems) in the mathematical system, namely number theory (arithmetic), algebra, geometry (which talks about angles, lines, planes and space), analysis and the basics of mathematics. The 2013 curriculum, through its content standards, requires that for tertiary level courses in the mathematics study program, one of them is Geometry. Geometry is an important subject for students to master because it is used in their daily lives to solve a variety of problems, both explicitly and implicitly. Mathematical power is the ability to deal with difficulties in both mathematical and real-life problems. Therefore, how is Geometry learning carried out to develop students' mathematical power (specifically called Geometric power)? When an educator gives a concept of mathematical information to students, and they also get it through reading, then at that time, there is a transformation of mathematical information from communicator to communicant. The response given by the communicant is the communicant's interpretation of the information. In studying mathematics, it is hoped that students can feel the usefulness of learning mathematics. As stated in the 2013 curriculum learning process standards, one of the student's abilities is communication skills. Meanwhile, in NCTM, one of the standards for student abilities is students' mathematical communication skills (Putri et al., 2022).

According to Ria Deswita, mathematical communication skills are abilities that students must have because, in the 2013 curriculum, one of the mathematical competencies that students must achieve is having the ability to communicate mathematical ideas clearly and effectively (Deswita & Kusumah, 2018). According to Greenes et al. (1992), mathematical communication has the role of (1) a central force for students in formulating mathematical concepts and strategies; (2) success capital for students regarding approaches and solutions in mathematical exploration and investigation; and (3) a forum for students to communicate with friends to obtain information, share thoughts and discoveries, brainstorm opinions, evaluate and sharpen ideas to convince others. On the other hand, Baroody stated that there are at least two critical reasons why communication in mathematics learning needs to be developed among students, including mathematics is not just a tool for thinking, a tool for finding patterns, solving problems or drawing conclusions, but mathematics is also an activity. Social in learning: mathematics is a vehicle for interaction between students and

teachers (Baroody, 1998). Furthermore, these reasons show that mathematical communication is a crucial ability that students must develop (Nisa et al., 2020).

Suriasumantri (1988) Wrote: "Mathematics is a language that symbolizes a series of meanings of statements we want to convey. The ability to communicate is one of the requirements that play an essential role because it helps organize thoughts and connect ideas with other ideas so that they can fill in things lacking in the student's entire network of ideas. According to Senjayawati, mathematical communication is divided into written and oral (Nisa et al., 2020). According to Saputra et al. (2023), communication skills are students' skills in expressing mathematical ideas orally, in writing, in pictures, diagrams, using natural objects, or using mathematical symbols.

Apart from the communication skills that students must have, the mathematical disposition is an essential ability that students must develop. According to Zulmiah, a mathematical disposition is the tendency to view mathematics as applicable and have a positive attitude towards mathematics (Zulmiah et al., 2023). A cheerful student's mathematical disposition is very much needed in students' mathematical communication skills because expressing ideas orally and in writing requires self-confidence, flexibility, perseverance, interest, curiosity, and creativity (Winarni et al., 2021). The importance of having mathematical communication skills and mathematical dispositions above is contained in the objectives of the Education Unit Level Curriculum (KTSP, 2006): students can understand mathematical concepts and the ability to communicate mathematical thoughts or ideas using symbols, tables, diagrams or other media, as well as have a positive attitude (disposition) towards the usefulness of mathematics in life. The example is curiosity, attention, interest in studying mathematics, and a tenacious and confident attitude in solving problems. KTSP 2006 recommends that mathematics learning begins with introducing issues appropriate to the situation (contextual problems), and then gradually, students are guided comprehensively.

Wardani (2008) Defines mathematical disposition as interest and appreciation for mathematics, namely the tendency to think and act positively, self-confidence, curiosity, perseverance, enthusiasm in learning, persistence in facing problems, flexibility, willingness to share with others, and reflection in mathematical activities (doing math). Zaozah and Maulana (2017), Students with a high mathematical disposition tend to be more persistent and confident in solving problems. In line with that, Fairus stated that mathematical disposition is a person's attitude or affective ability to view mathematics as something that can foster good character, such as self-confidence, high interest in learning, persistence, seriousness in solving problems, thinking flexibly, and reflecting after studying mathematics (Fairus et al., 2023). Sukamto (2013), Mathematical disposition is the tendency to think and act positively. Rahmalia et al. (2020), A mathematical disposition is a strong drive, awareness, or tendency to learn mathematics. Mathematical disposition is the tendency to consider and view mathematics as practical, to have a positive attitude towards mathematics and to be accustomed to carrying out mathematical activities (Andini et al., 2023). Mathematical disposition relates to students' ability to solve mathematical problems, which includes an attitude of confidence, perseverance, interest, and flexible thinking to explore various alternative problem solutions.

In implementation in the field, geometry lectures for students in the class of 2022 at UIN Imam Bonjol Padang used various approaches and strategies. They could understand mathematical concepts and no longer use a rote system. The results of

research conducted by Nari (2015) regarding the analysis of the mathematical problem-solving abilities of Tadris mathematics students in the transformation geometry course showed that the mathematical communication aspect in the mathematical problem-solving indicators had not shown maximum results. It could be seen in indicators 3 and 4 in solving mathematical problems regarding the accuracy of the sequence of steps and the correctness of the writing to explain the steps, which had not shown satisfactory results in each analysis group.

Based on field observations at the inaugural meeting of the plane and space geometry course for the 2022/2023 academic year, information was obtained that many students were reluctant and unable to answer orally and in writing about several basic principles and definitions in geometry. For example, when asked about the meaning of a point, it is seen from various dimensional shapes (line, plane, space or point as a single element). It is because students are unable to connect real objects, pictures, and diagrams to mathematical ideas, resulting in the inability of students to explain things both orally and in writing. It is one of the indicators of mathematical communication skills that prospective teaching students must master to prepare for the field.

An appropriate and suitable learning strategy is needed to overcome this problem. Therefore, educators should give themselves the freedom to use their knowledge and intellectual skills to achieve the cognitive domain, which shows educational goals directed toward communication skills and an attitude of respect for mathematics, as demonstrated by an excellent mathematical disposition. Appropriate learning strategies must be implemented to improve communication and mathematical disposition. One of the learning strategies that is considered suitable is trying to apply a problem-based learning strategy. Problem-based learning is a learning strategy that begins with presenting a problem designed in a context relevant to the material being studied (Gonzalez-Argote & Castillo-González, 2024). The problem-based learning strategy is cooperative learning, where students will find it easier to understand complex concepts if they can discuss these problems with their friends. Students are allowed to express their opinions, hear their friends' views, and discuss the difficulties given together. Cooperative learning is hoped to improve communication skills and creativity in solving mathematical problems. When given a mathematical problem, students must understand, reason, and solve it creatively. Students must communicate and express their creative ideas to friends and educators during discussions and presentations.

In problem-based learning strategy activities, supporting media, the Geogebra application, will be implemented to gain an understanding emphasizing communication and mathematical disposition. Geogebra software's benefits in learning mathematics are that it can produce geometric drawings quickly compared to using a pencil, ruler or compass. (Tanjung et al., 2023). GeoGebra Media is a dynamic program with facilities for visualizing or demonstrating mathematical concepts and a tool for constructing mathematical concepts (Rochim, A., & Herawati, 2021).

Based on the above context, the author is interested in researching the application of GeoGebra-assisted problem-based learning strategies to improve the mathematical communication skills and disposition of Tadris mathematics students in the Plane and Space Geometry course.

Research Methods

This research was carried out in the plane and space geometry course at UIN Imam Bonjol Padang, odd semester 2023/2024. All first-semester students were the research

population, and the sample was divided into two groups, each with class I TMTK-A consisting of 25 people as the experimental group and class I TMTK-B composed of 24 people as the control group. This quantitative research uses a quasi-experimental type of research using a control group design. In this design, two groups are selected randomly and given a posttest to determine whether there are differences between the experimental and control groups.

The research design used was a control group design (Sevilla et al.: 106), designed as follows:

Table 1. Research Design

Class	Random sampling	Treatment	Post-tes
Experiment	**R**	**X**	**O_2**
Control	**R**		**O_2**

Note :
R = Random sampling
O_2 = Post-tes (Final test)
X = Treatment using problem-based learning assisted by Geogebra.

Data were collected in this research using learning outcomes test mathematical communication skills of 5 questions and a mathematical disposition questionnaire of 35 statements. Preparing learning outcomes for mathematical communication skills starts with preparing a grid of questions that includes subtopics, measurable abilities, indicators, and several questions. After creating a grid of questions, proceed with compiling questions and assessment rules. Before being used in research, the results of learning the mathematical abilities of these questions have been well-validated by experts.

After preparing the first question, the next step is to prepare mathematical disposition ability questions. The mathematical disposition ability questionnaire reveals students' mathematical disposition (Geometry) abilities toward problem-based learning in general learning. The questionnaire used is a Likert scale. This questionnaire was given to the experimental group students after the final test. The answers to the questionnaire in this study, as expressed by Ruseffendi (2018), were Very Often, Often, Sometimes) Rarely, and Very Rarely. Before the questionnaire items are formulated, a questionnaire grid is first drawn up. Based on the questionnaire grid, a mathematical disposition questionnaire was prepared. The questionnaire was validated first before being distributed to students.

Results and Discussion

After carrying out tests in the two sample classes, data was obtained regarding the results of tests on students' mathematical communication skills for the material Triangles, Quadrilaterals and Drawing Shapes Using Anchors and Ruler. Tests were given to TMTK-A students whose learning was carried out by applying a geogebra-assisted problem-based learning strategy, and tests were also given to TMTK-B students whose learning was carried out by applying conventional learning methods.

Table 2. Final Test Data Processing Results

Class	N	$\bar{x}$	Max	Min	S_i	S_i^2
Experiment	25	81.00	97	48	13.73	188.43
Control	24	71.16	97	30	18.97	359.78

Table 2 shows that the average test for students' mathematical communication skills in the experimental class is higher than the average in the control class. It means that the student's scores in the experimental class were higher than those in the control class. Judging from the distribution, the control class has a broader distribution than the experimental class. In contrast, in terms of standard deviation, the experimental class has a more minor standard deviation compared to the control class.

The average results of students' mathematical communication skills for each indicator are presented in Table 3:

Table 3. Average Indicator of Mathematical Communication Skills

No.	Indicator of mathematical communication skills	Question Number	Average	
			Experiment	Control
1.	Connecting objects	1-5	80.6	52.0
2.	Explaining ideas		86.2	778.2
3.	Declare an event		76.2	74.8
Total			243,0	205.0
Average			81	71.1

From the analysis test, each indicator of communication skills was generated. In indicator one, the maximum score for all questions is 20. For the experimental class, the average obtained for the first indicator is 80.6, while in the control class, the average obtained is 52.0. From the average difference, it can be seen that the experimental class is superior in communication skills for indicator 1, namely regarding expressing images, diagrams, language, symbols, expressions or mathematical models in their language.

In indicator two, the maximum score for all questions is 20. The average for the experimental class for the second indicator is 86.2, while in the control class, the average is 72.2. From the average difference, it can be seen that the experimental class is superior in communication skills for indicator 2, namely about expressing a situation in the form of pictures, diagrams, language, symbols, expressions or mathematical models.

In indicator three, the maximum score for all questions is 20. The average for the experimental class for the third indicator was 76.2, while in the control class, the average obtained was 74.8. From the average difference, it can be seen that the experimental class is superior in communication skills for indicator 3, namely about using terms, mathematical notations and structures to present ideas, describe relationships and situation models.

These three indicators of communication skills are indicators of written communication skills. Based on the analysis of these indicators, it can be seen that there are differences in the mathematical communication abilities of students in the two research classes. After testing the hypothesis, students' mathematical communication

skills and problem-based learning strategies, assisted by Geogebra, are better than those of conventional learning. It can be seen in Table 4:

Table 4. Hypothesis Test Results Results of Student Mathematical Communication Ability Tests

Class	n	$\bar{x}$	s	T	t_{α}
Experiment	25	81.00	13,73	2.197	1.677
Control	24	71.18	18,97		

Based on the researchers' observations during the research, the learning process using problem-based learning strategies assisted by Geogebra was quite capable of improving students' mathematical communication skills. At each meeting, the researcher first informed students about the learning objectives and the lesson material that would be provided. Next, the researcher provided apperception and motivation to students about the importance of understanding the material about flat shapes, triangles, quadrilaterals and painting shapes, which were the primary materials that will be used when they become teachers in the future. This material is essential and closely related to students' daily lives as individuals and in their environment. Then, the researcher explained the process that would be carried out using problem-based learning strategies assisted by Geogebra and explained what students had to do. After the researcher provided material to students by orienting them to the problem, students were asked to organize the problem so they could communicate well about the mathematical problem.

Depdiknas (2002), stated that the mathematical abilities selected and determined had been designed according to the skills and needs of students so that they could develop optimally. These competencies related to communication must be achieved while the learning process is taking place in the classroom. Maulyda et al. (2020), Mathematical communication skills are a comprehensive understanding of creating writing, reading various materials, listening to readings, studying, interpreting and evaluating ideas, symbols, terms and mathematical information. Ansari (2016), Mathematical communication skills are students' communication abilities to communicate mathematical ideas or concepts verbally or in writing.

The prominent indicator of communication skills is the indicator of explaining ideas, where the experimental class gets the highest score compared to the other indicators. It means that almost all of them can express their mathematical ideas. It is the same as what was found in (Riza & Mirna, 2020), which states that the most prominent mathematical communication ability of students in each group based on their ability level is in indicator 1, namely, expressing mathematical ideas in writing.

After carrying out a test on students' mathematical communication skills by filling out mathematical disposition questionnaires in the two sample classes, data was obtained regarding the results of students' mathematical disposition questionnaires for the material Triangular, Quadrilateral and Drawing Shapes Using Anchors and Ruler. This questionnaire is to see how students behave in solving mathematical problems with indicators of mathematical communication skills. The average results of students' mathematical communication skills for each indicator are presented in Table 5.

Table 5. Final Results of Calculation of Values for Each Student's Mathematical Disposition Indicator

Mathematical Disposition Indicator	Questionnaire Statement Number	Average	
		Experiment	Control
Confidence	1-4	74.4	68.9
Flexibility	5-7	83.7	70.20
Strong determination	8-12	75.8	68.83
Curiosity	13-22	77.8	69.08
Reflection	23-28	73.1	65.00
Rate the application	29-32	75.8	67.08
Appreciation	33-35	75.5	68.05
Average		76.59	68.16

Based on Table 5, the mathematical disposition shows a difference in the average value between the experimental and control classes. The mathematical disposition questionnaire contains some questions that show individual students' attitudes towards geometry and their habits in dealing with mathematical problems, especially geometry.

Then, a test of the difference between the two averages of the mathematical communication ability test data was carried out using the t-test. From the results of the t-test analysis with $\alpha = 0.05$, tcount = 2.18 and ttable = 1.677. It shows that the tcount value is more significant than t_{table}. Based on the hypothesis testing criteria, H0 is rejected; this means that students' mathematical disposition abilities by applying Geogebra-assisted problem-based learning strategies are better than students' mathematical disposition abilities by applying conventional learning methods in the material of Triangle, Quadrilateral and Drawing Figures Using Anchors and Ruler. It can be seen in Table 6.

Table 6. Test Results of Student Disposition Questionnaire Hypothesis

Class	n	$\bar{x}$	s	T	t_{α}
Experiment	25	133.68	22.91	2.18	1.677
Control	24	119.21	23.55		

Based on Table 6, t⟦>t⟧_α is obtained. Thus, it can be concluded that the mathematical disposition of students with geogebra-assisted problem-based learning strategies is better than conventional learning. Apart from the analysis and t-test results, differences in students' mathematical disposition abilities in the two research classes can also be observed during the lecture process. The TMTK I A class whose learning uses problem-based learning strategies looks more active and persistent in solving problems. Mulyono (1998) stated that disposition toward mathematics changed students' tendencies in viewing and behaving towards mathematics and acting when learning mathematics. Isrok'atun (2020), Mathematical disposition is a student's strong desire, awareness and dedication to learn mathematics and carry out various mathematical activities.

What stands out most is the statement of flexibility indicators on students' mathematical disposition abilities in the experimental and control classes. It can be

concluded that students generally have strong flexibility abilities compared to other indicators. It also aligns with the results of Tri Dwi Larosa Simanjuntak's research, which states that indicator 2 (flexibility) is the dominant indicator obtained most by students. It means that students are most interested in investigating mathematical ideas and finding alternative methods for solving given mathematical problems (Simanjuntak et al., 2018).

Problem-based learning strategies and small group discussions could make students confident in solving mathematics (geometry) problems. They felt more free and brave in communicating their ideas to group friends or between groups to provide alternative solutions to the contextual and open-ended issues given. In lectures on rectangular plane shapes, students were divided into six groups of 5 to 6. Each group was named square, rectangle, parallelogram, trapezoid, rhombus and kite. Each group member was asked to make a variety of flat shapes using a piece of paper according to the name of their respective group. From the discussion, it was clear that students were quite flexible in exploring mathematical ideas based on the structures they had produced. They tried various alternative methods to solve the problem. They felt they were highly curious because the material presented was contextual, open-ended, and natural for students.

Conclusion and Suggestions

The results of research in class 1 TMTK-A and class 1 TMTK-B, Tadris Mathematics Study Program, UIN Imam Bonjol Padang, the academic year 2022/2023, showed that students' communication skills and mathematical disposition in problem-based learning assisted by Geogebra were better than communication skills and mathematical disposition students in conventional learning. Geogebra-assisted problem-based learning helped students hone their communication skills and mathematical disposition. Therefore, Geogebra-assisted problem-based learning can be used as an alternative to learning on campus.

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